Therefore, D is simply

$$D = \frac{SAR_{T,BON \rightarrow LGR}}{SAR_{I,BON \rightarrow LGR}} = \frac{(1-L_T)S_{T,us}}{(1-L_I)S_{I,us}}$$

Note that we assume the same natural estuary/ocean survival ($S_{e/o}$) for both in-river and transported fish.

ii. D is typically below 1.0 for Snake River spring-summer Chinook salmon and steelhead, providing one measure of latent mortality for transported fish, but not an absolute measure--it is only relative to in-river fish. This latent mortality may result from stress experienced on the barge, disruption of timing to the estuary, or increased straying or fallback of adult migrants. While we cannot identify specific mechanisms that lead to $D < 1.0$, we can directly estimate D, because it relates to the juvenile survival and SAR for in-river migrants. Estimates of D for wild spring/summer Chinook are presented in the following table:

Migration year	NMFS (Williams et al. 2005)	CSS (Berggren et al. (2005)
1994	0.68	0.36
1995	0.46	0.42
1996	1.08	0.92
1997	0.50	0.40
1998	0.43	0.55
1999	0.64	0.72
2000	0.34	0.32
2001		2.16
2002		0.44
2003		0.69

D is not an absolute measure of the latent mortality of transported fish, because the overall amount of delayed mortality for transported fish is a

consequence of both *D* and the level of hydropower-related delayed mortality of in-river migrants.

c. *Sub Hypothesis: Passage of seaward migrating juvenile fish through (inriver) and around (transportation) the FCRPS causes delayed mortality to salmon populations by delaying or accelerating arrival of smolts to the estuary.*

i. Evidence

1. Seasonal Trends in SARs: Previous analysis suggests that there may be seasonal trends in transport-inriver ratios (TIR) of SARs and D values for hatchery and wild yearling migrant Chinook. These analyses have suggested that TIR (and D) tends to increase over the migration season (e.g. see Figure C2 in Marmorek et al. (2004). Such a pattern may reveal one mechanism by which hydrosystem experience can affect survival below Bonneville dam, and it can have implications for transportation strategy. Patterns for steelhead are not as pronounced and average TIRs have tended to be above 1 across the migration season.

Data from PIT-tagged wild spring/summer Chinook were used (Fish Passage Center unpublished data) to investigate the consistency of seasonal trend between years, from migration years 1998-2003. The method used to explore within-season variation was adapted from the method used in the Collaborative Systemwide Monitoring and Evaluation Project (CSMEP) Hydro Group Data Quality Objectives process (Porter et al. 2005) and in the post-Bonneville mortality work group for the NMFS COMPASS modeling process (P. Wilson). The method uses an assumption of binomial sampling error in the SAR estimates to remove measurement error variance from total variance to estimate inter-annual process error (environmental) variance. Instead of using data from each migration year in the aggregate to estimate environmental variance in

SARs and TIRs, here the data from each of three periods within the migration season is treated separately. The resulting distributions can then be used to derive estimates of, for instance, the frequency with which true TIR would be greater than one for each of the time periods. In this analysis, Lower Granite Dam (LGR) is the only transport project investigated (though the exercise could be performed for other projects). Unlike the CSMEP and post-Bonneville hypothesis analyses submitted to the post-Bonnneville group, the in-river fish used are "C1" fish—PIT-tagged fish detected at LGR dam. The "true control" (C0) fish used in previous applications of this method cannot be used to estimate season trends in SAR and TIR; since a C0 smolt is not detected at LGR (or any of the collector projects), a date of LGR passage cannot be accurately assigned to it. Because the C1 group has typically shown lower annual SARs than the "true controls" (Berggren et al. 2005) the seasonal TIRs calculated here likely have some positive bias.

Each migration year, the season was broken into three periods based on detection date at LGR: Before April 26, April 26 to May 10, and after May 10. This resulted in approximately equal total numbers of PIT-tagged fish in each group, over the six year period. Summary information from the resulting TIR distributions is presented in the table below. It appears that TIR (and consequently, D) increases substantially over the season.

Period	T smolts	C1 smolts	Median TIR	Prob TIR > 1
Before 4/26	4059	15380	0.36	15%
4/26 – 5/10	2366	19568	1.29	59%
After 5/10	3022	15348	2.30	91%

Inspecting the distributions of transport and in-river SARs suggests that although transport SAR is modestly higher late in the season than earlier (Fig. 11a), the primary reason for the increasing trend in TIRs is that in-river (C1) SARs decline dramatically in the middle and end of the season

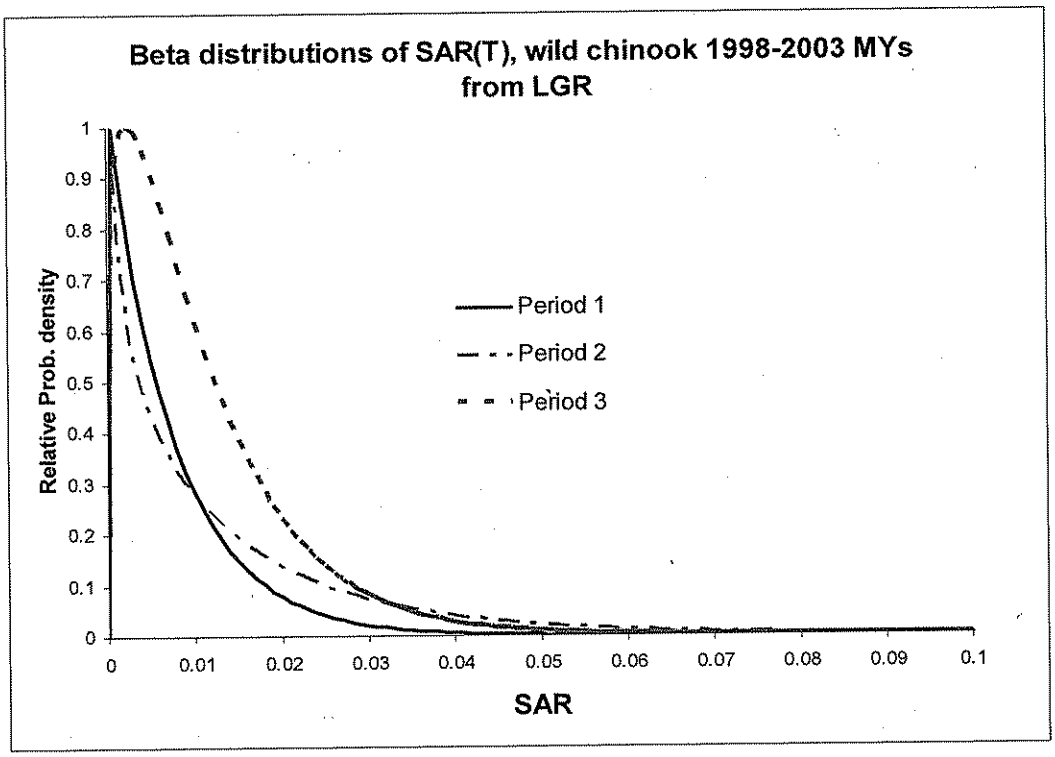
(Fig. 11b). The decline in SAR of in-river (C1) fish as the season progresses is consistent with the hypothesis that the protracted migration and late arrival in the estuary is in part responsible for elevated levels of post-Bonneville mortality as a consequence of the hydrosystem experience.

The seasonal TIRs contain some positive bias because the true controls (C0), which migrate through spill and turbine routes at collector dams, have shown higher SARs than fish bypassed at one or more of the collector dams (Berggren et al. 2005). The SAR distributions for true controls (C0) and smolts detected and returned to the river at LGR dam (C1) using the same method are shown in Figure 12. If in-river survivals are similar for C1 and C0 groups, as generally assumed, the differential SAR is evidence of delayed mortality for bypassed fish (see Budy et al. 2002). It is also possible that the trend in increasing TIRs may not be as pronounced for C0 fish as seen for C1 fish (Figure 11), particularly in years when the spill program is implemented.

A number of mechanisms may explain the temporal patterns of SARs. In-river migrants face migration delays through the FCRPS, which may have different consequences depending on seasonal timing. For example, later in-river migrants may:

- face increased exposure to elevated temperatures, contributing to poorer condition upon estuary arrival
- be further along in the smoltification process and be more vulnerable to migration delay
- miss the optimal window of estuary and early ocean environmental conditions
- face increased predation rates in the lower Columbia River mainstem, estuary and ocean

(a)



(b)

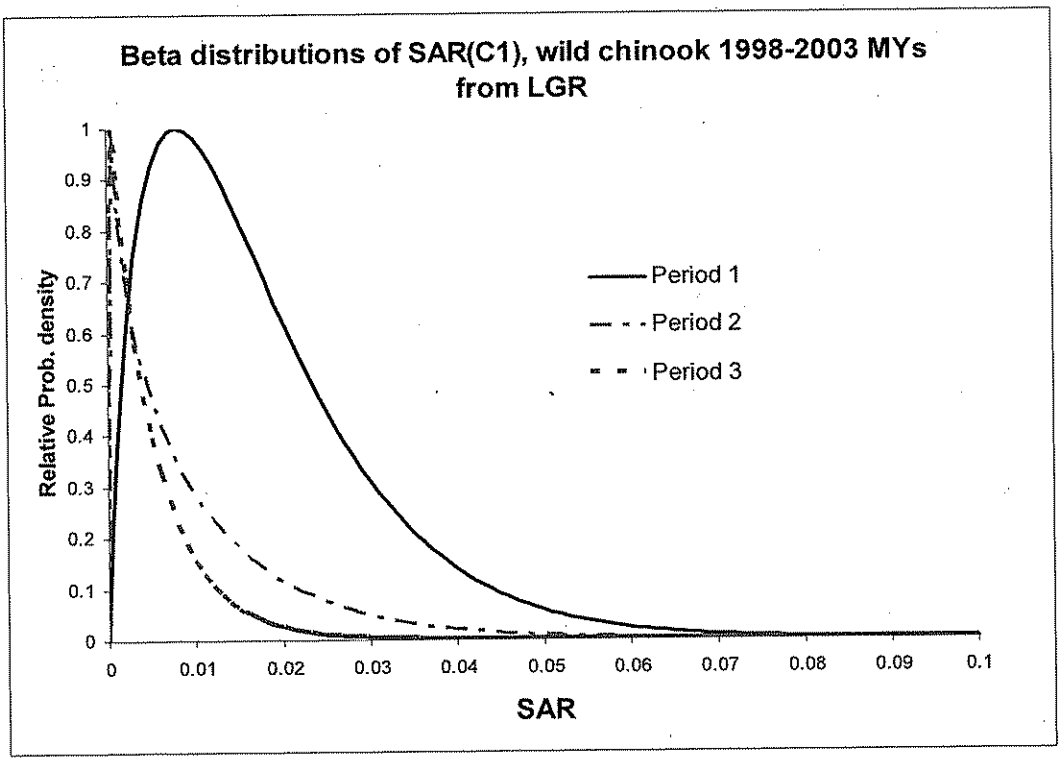


Figure 11. Distributions of SAR for smolts detected at Lower Granite and transported (a) or returned to the river (b), for the three migration periods.

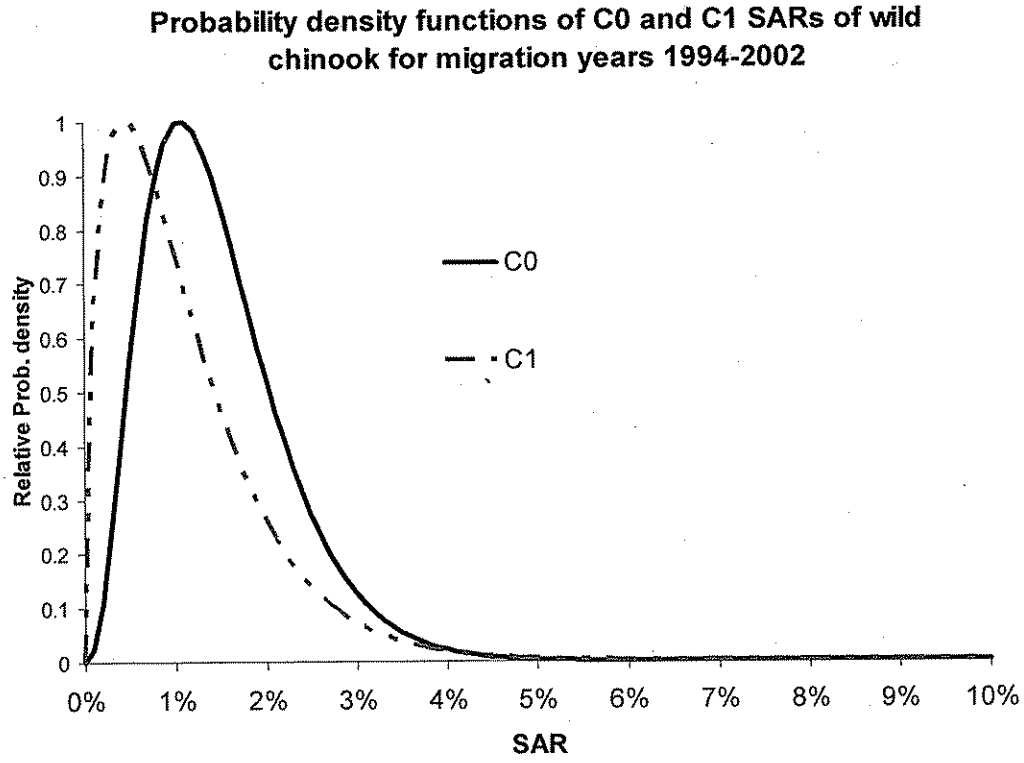


Figure 12. Distributions of SAR for true controls (C0) and smolts detected at Lower Granite and returned to the river (C1), 1994-2002 migration years.

2. SARs by Bonneville Arrival Timing: The numbers of Snake River wild spring/summer Chinook PIT-tagged smolts and returning adults from the CSS study groups T0, C0, and C1 were summarized for smolt arrival timing based on their detection at Bonneville Dam, at John Day Dam or trawl samples below Bonneville Dam (T. Berggren, pers. comm.), 2000-2003 migration years. Bonneville arrival dates for smolts detected only at John Day Dam or in the trawl were corrected for median travel times to or from the Bonneville detector. Numbers of PIT-tagged wild John Day River spring Chinook smolts and adults for the same arrival periods and years were included in the summary. SARs in this case represent smolts from Bonneville dam to adult returns to Bonneville dam.

The arrival timing of John Day wild smolts was primarily late April through May all years (similar to Snake River wild smolt timing at Lower Granite Dam). A combination of delayed migration of in-river smolts and transportation has altered the arrival timing of Snake River migrants to the lower Columbia River estuary. All groups of Snake River wild Chinook consistently experienced lower SARs (Bonneville to Bonneville) than John Day wild Chinook within the same arrival time period and for the season (Fig. 13, 14). In 2000 and 2001, SARs for the earliest transport Snake River groups apparently approached 10% (Fig. 13), but these were based on small sample sizes ($n<70$) and the pattern did not continue in subsequent years[2].

The disparity between SARs for John Day River and Snake River wild Chinook, when they arrive to the lower Columbia River at the same time, provides additional support for the hypothesis of delayed hydrosystem mortality, and may shed light on likely mechanisms. The Comparative

[2] No adults returned from the earliest period from 68 transported smolts in 2002; and 1 returned from 661 transported smolts in 2003.

Survival Study analysts plan to more formally investigate the SAR patterns based on arrival timing and other factors in future years.

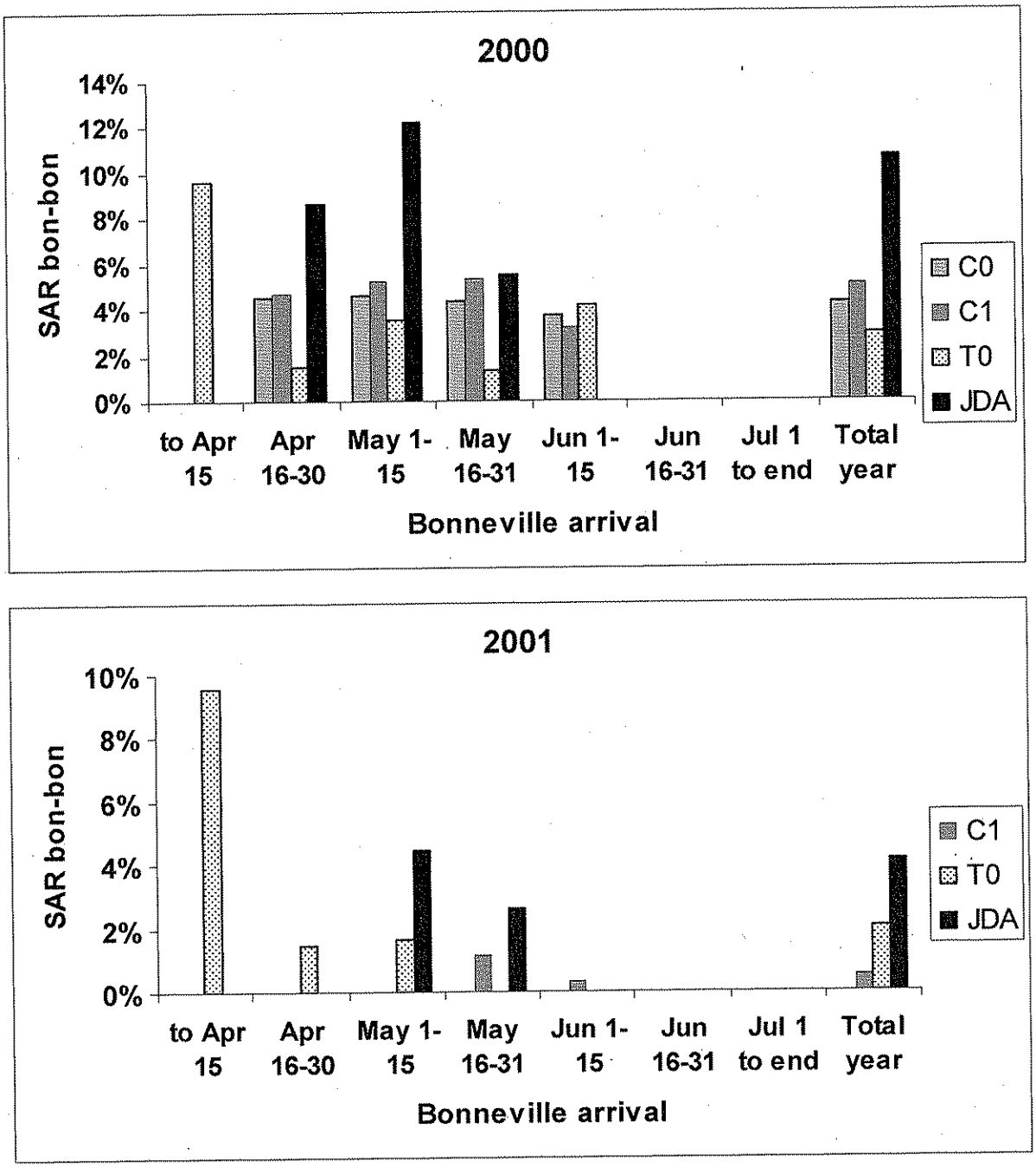


Figure 13. SAR by Bonneville arrival date and group for Snake River wild spring/summer Chinook (T0, C0, and C1) and John Day wild spring Chinook, 2000-2001. SARs calculated for all smolt groups > 50.

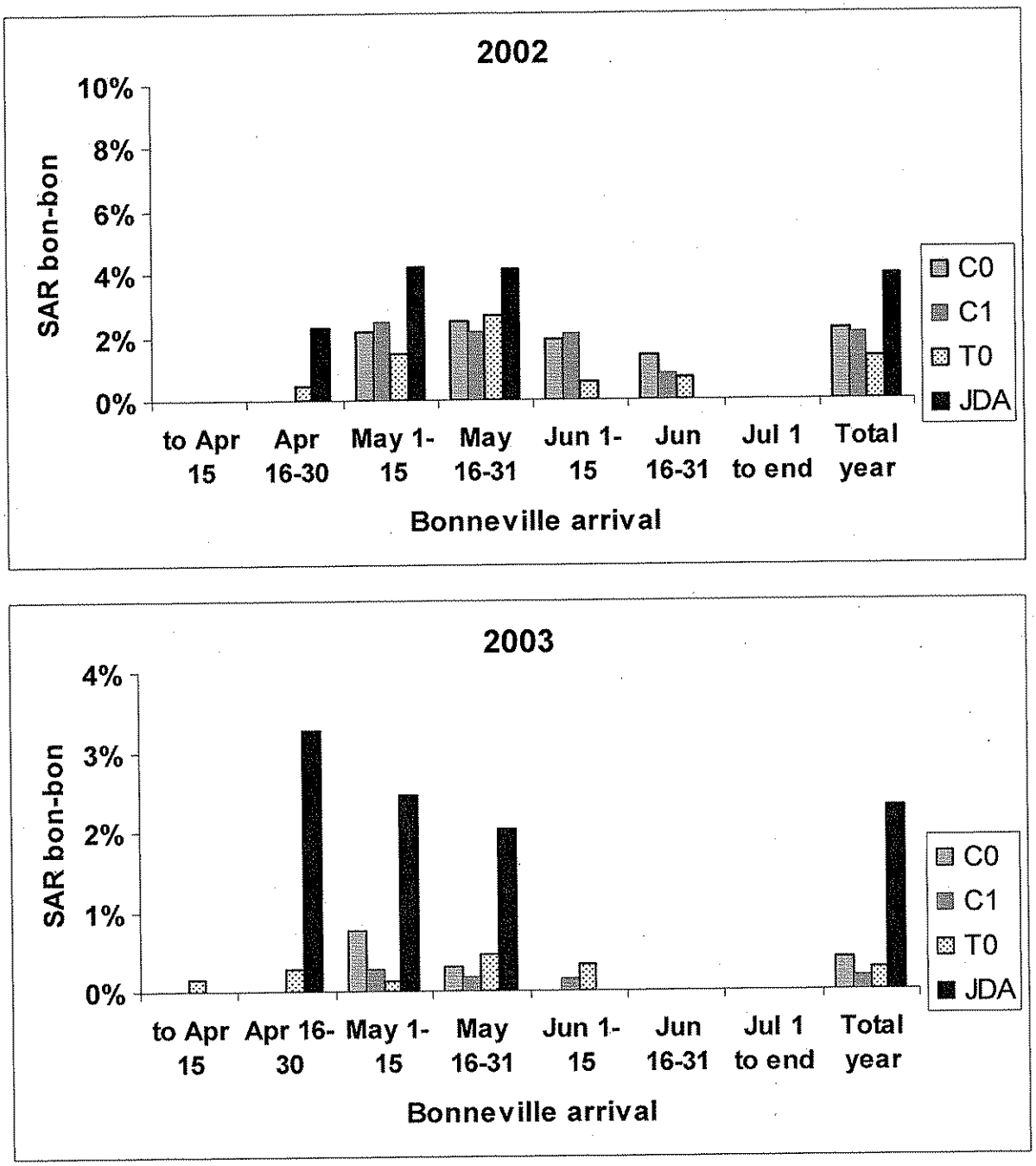


Figure 14. SAR by Bonneville arrival date and group for Snake River wild spring/summer Chinook (T0, C0, and C1) and John Day wild spring Chinook, 2002-2003. SARs calculated for all smolt groups > 50. Adult returns from 2003 complete only through 2-ocean returns.

VI. Summary and Conclusions

Based on our findings from multiple analyses, the hypothesis that a portion of the mortality that occurs in the estuary and ocean life stage is due to cumulative impacts of the FCRPS appears highly plausible. We explicitly described this hypothesis of delayed mortality relative to development and operation of the FCRPS and variants of this main hypothesis. We provided a summary, from the literature, for the mechanisms and the lines of evidence supporting this hypothesis.

We presented multiple analytical approaches addressing this delayed mortality for Snake River spring/summer Chinook. Results from updated and expanded analyses comparing upriver and downriver population performance continued to show that development and operation of the FCRPS was a key factor influencing levels of delayed mortality of Snake River spring/summer Chinook.

We developed new analyses relating survival rates for Snake River spring/summer Chinook to FRCPS and ocean/climate conditions, which did not rely on comparing upriver and downriver population performance. The analysis of Snake River populations alone included ocean/climatic variables, and water travel time relative to spawner-recruit residuals, smolt-to-adult return rates (SARs) and survival during the first year of ocean residence. Water travel time increased as the FCRPS was developed, and populations experienced a wide range of ocean/climatic conditions during the study period. Evaluation of the spawner-recruit residuals, SARs and early ocean survival showed that survival was related to water travel time, providing supporting evidence that there is a significant component of the survival during early ocean residence that is accounted for by delayed mortality, and related to construction and operation of the FCRPS. These analyses compliment the results from the upriver/downriver population performance model.

From this information there appears to be a delayed mortality component to survival during early ocean residence that is related to construction and operation of the FCRPS;

however survival rates are also strongly related to the PDO and upwelling indices (measures of oceanic climatic conditions). The magnitude of delayed hydrosystem mortality may be modified by ocean conditions.

The FCRPS has delayed migration of in-river fish; with later arriving components of the population exhibiting lower SARs. Additional support for delayed mortality associated with passage through the FCRPS is provided by within-season patterns of SARs for in-river migrants, SARs of bypassed vs. true in-river migrants, and the relatively higher SARs of John Day wild Chinook when they experience the same arrival timing at Bonneville Dam as Snake River wild Chinook.

The results of these multiple analyses provide compelling evidence that passage through the FCRPS strongly influences levels of delayed mortality of in-river migrants for these populations.

Literature cited

Berggren, T. and 7 co-authors. 2005. Comparative survival study (CSS) of PIT-tagged spring/summer chinook and PIT-tagged summer steelhead. 2005 annual report, mark/recapture activities and bootstrap analysis. BPA Contract 19960200. Prepared by Fish Passage Center and Comparative Survival Study Oversight Committee. December 2005. 155 pp.

Bickford, S. A., and J. R. Skalski. 2000. Reanalysis and interpretation of 25 years of Snake-Columbia River juvenile salmonid survival studies. North American Journal of Fisheries Management 20:53-68.

Budy, P., G.P. Thiede, N. Bouwes, C.E. Petrosky, and H. Schaller. 2002. Evidence linking delayed mortality of Snake River salmon to their earlier hydrosystem experience. North American Journal of Fisheries Management 22:35-51.

Congleton, J. L., T. Wagner, J. Evavold, J. Hafner, D. Fryer, and B. Sun. 2004. Evaluation of physiological differences in transported, in-river migrating, and multiple bypassed juvenile salmon. 2002 Annual report of the Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, to the U.S. Army Corps of Engineers, Walla Walla, Washington.

Deriso, R.B., D.R. Marmorek, and I.J. Parnell. 2001. Retrospective patterns of differential mortality and common year effects experienced by spring and summer chinook salmon (*Oncorhynchus tshawytscha*) of the Columbia River. Canadian Journal of Fisheries and Aquatic Sciences 58:2419-2430.

Ferguson, J.W., R.F. Absolon,T.J. Carlson, and B.P. Sandford. 2006. Evidence of delayed mortality on juvenile Pacific salmon passing through turbines at Columbia River dams. Transaction of the American Fisheries Society 135:139-150.

Karieva, P., M. Marvier, and M. McClure. 2000. Recovery and management options for spring/summer chinook in the Columbia River Basin. Science 290:977-979.

Levin and Tolimieri 2001 Differences in the impacts of dams on the dynamics of salmon populations. Zoological Society of London. Animal Conservation 4: 291-299.

Long, C. W., R. F. Krcma, and F. J. Ossiander. 1968. Research on fingerling mortality in Kaplan turbines. National Marine Fisheries Service, Northwest and Alaska Fisheries Center, Seattle, Washington.

Mantua, N.J. and S.R. Hare, Y. Zhang, J.M. Wallace, and R.C. Francis,1997: A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of

the American Meteorological Society, 78,pp. 1069-1079.

Marmorek, D.R., C.N. Peters, J. Anderson, L. Barnthouse, L. Botsford, N. Bouwes, P. Budy, T. Cooney, R. Deriso, J. Gieselman, A. Giorgi, J. Hayes, R. Hinrichsen, M. Jones, L. Krasnow, O. Langness, D. Lee, C. McConnaha, C.M. Paulsen, R. Peterman, C.E. Petrosky, C. Pinney, H. Schaller, S. Smith, C. Toole, E. Weber, J. Williams, P. Wilson, and R. Zabel. 1998. Plan for Analyzing and Testing Hypotheses (PATH): Weight of Evidence report. Compiled and edited by ESSA Technologies, Ltd., Vancouver, B.C. Available from Bonneville Power Administration, Portland, Oregon (http://www.efw.bpa.gov/Environment/PATH/reports/ISRP1999CD/PATH%20Reports/WOE_Report/.)

Marmorek, D.R., M. Porter, I.J. Parnell and C. Peters, eds. 2004. Comparative Survival Study Workshop, February 11-13, 2004: Bonneville Hot Springs Resort. Report compiled and edited by ESSA Technologies Ltd., Vancouver, B.C. for Fish Passage Center, Portland, OR and the US Fish and Wildlife Service, Vancouver, WA. 137 pp.

Mathur, D., P. G. Heisey, E. T. Euston, J. R. Skalski, and S. Hays. 1996. Turbine passage survival estimation for chinook salmon smolts (*Oncorhynchus tshawytscha*) at a large dam on the Columbia River. Canadian Journal of Fisheries and Aquatic Sciences 53:542-549.

Navarro, J. E., D. J. McCauley, and A. R. Blystra. 1996. Turbine passage at four low-head hydroelectirc facilities in northeast Michigan. North American Journal of Fisheries Management 16:182-191.

Pacific Fisheries Environmental Laboratory. 2006. PFEL's Historical Upwelling Index for 26 positions along the Eastern Pacific coast at each 3 degrees of latitude from 21N to 60N, and from 45S to 15S. http://www.pfeg.noaa.gov/products/PFEL/modeled/indices/upwelling/upwelling.html

Peters, C.N. and D.R. Marmorek. 2001. Application of decision analysis to evaluate recovery actions for threatened Snake River spring and summer chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 58:2431-2446.

Petrosky, C.E., H.A. Schaller, and P. Budy. 2001. Productivity and survival rate trends in the freshwater spawning and rearing stage of Snake River chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 58:1196-1207.

Petrosky, C.E. and H.A Schaller. *In prep 2006.* The relationship of Snake River stream-type Chinook survival rates to river and ocean conditions. Manuscript in preparation.

Porter, M., D.R. Marmorek and I.J. Parnell (eds.). 2005. Collaborative Systemwide Monitoring and Evaluation Project (CSMEP) – Year 2. 2005 Annual Report Project 2003-036-00. Report compiled and edited by ESSA Technologies Ltd., Vancouver, B.C. for Bonneville Power Administration, Portland, OR.

Pyper, B.J., F.J. Mueter, and R.M. Peterman. 2005. Across-species comparisons of spatial scales of environmental effects on survival rates of Northeast Pacific salmon. Transactions of the American Fisheries Society 134:86-104.

Raymond, H. L. 1979. Effects of dams and impoundments on migrations of juvenile chinook salmon and steelhead from the Snake River, 1966 to 1975. Transactions of the American Fisheries Society 108:505-529.

Schaller, H.A., C.E. Petrosky, and O.P. Langness. 1999. Contrasting patterns of productivity and survival rates for stream-type chinook salmon (*Oncorhynchus tshawytscha*) populations of the Snake and Columbia rivers Canadian Journal of Fisheries and Aquatic Sciences 56:1031-1045.

Schaller, H.A., C.E. Petrosky, and O.P. Langness. 2000. Reply to Zabel and Williams' comments on "Contrasting patterns of productivity and survival rates for stream-type chinook salmon (*Oncorhynchus tshawytscha*) populations of the Snake and Columbia rivers" by Schaller et al. (1999). Canadian Journal of Fisheries and Aquatic Sciences 57:1742-1746.

Schaller, H.A and C.E. Petrosky *in review*. Evaluating the influence of delayed mortality on Snake River stream-type Chinook salmon (*Oncorhynchus tshawytscha*). Submitted to North American Journal of Fisheries Management

Scheuerell, M.D. and J.G. Williams. 2005. Forecasting climate-induced changes in the survival of Snake River spring/summer Chinook salmon. Fisheries Oceanography 14:1-10.

Schreck, C.B., T.P. Stahl, L.E. Davis, D.D. Roby and B.J. Clemens. 2006. Mortality estimates of juvenile spring-summer Chinook salmon in the lower Columbia River and estuary: evidence for delayed mortality? Transaction of the American Fisheries Society 135:457-475.

Williams, J.G. 2001. Potential impact of *Renibacterium salmoninarum* on adult returns of Snake River spring/summer chinook salmon. Bull. Natl. Res. Inst. Aquaticul., Suppl. 5:55-59.

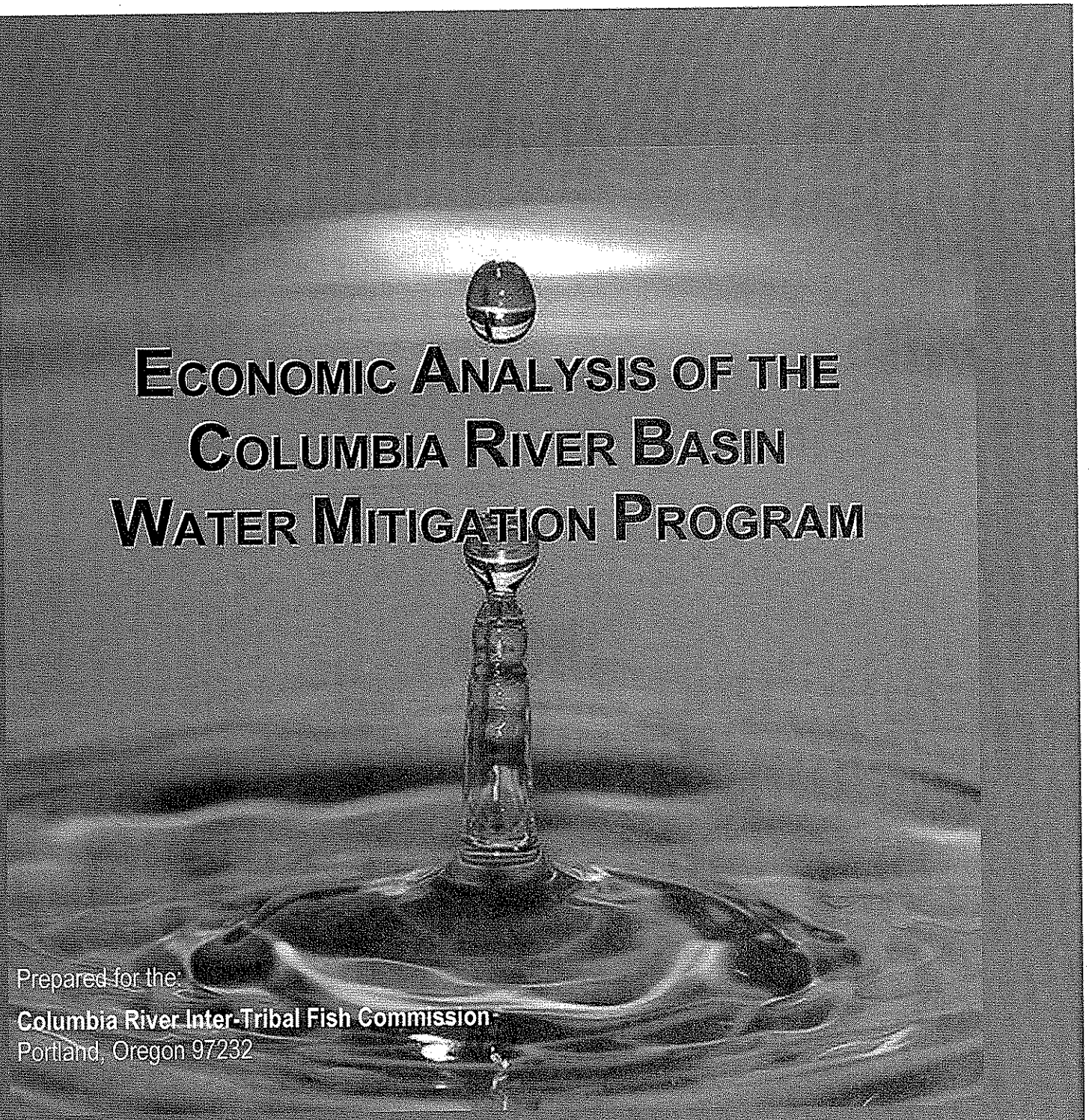
Williams, J. G., and G. M. Matthews. 1995. A review of flow and survival relationships for spring and summer chinook salmon, *Oncorhynchus tshawytscha*, from the Snake River Basin. Fisheries Bulletin 93:732-740.

Williams, J.G., S.G. Smith, R.W. Zabel, W.D. Muir, M.D. Scheuerell, B.D. Sandford, D.M. Marsh, R.A. McNatt, and S. Achord. 2005. Effects of the Federal Columbia River Power System on salmonid populations. NOAA Technical Memorandum NMFS-NWFSC-63. (http://www.nwfsc.noaa.gov)

Wilson, P.H. 2003. Using population projection matrices to evaluate recovery strategies for Snake River spring and summer Chinook salmon. Conservation Biology 17:782-794.

Zabel, R.W., and J.G. Williams. 2000. Comments on "Contrasting patterns of productivity and survival rates for stream-type chinook salmon (Oncorhynchus tshawytscha) populations of the Snake and Columbia Rivers" by Schaller et al. (1999). Canadian Journal of Fisheries and Aquatic Sciences 57:1739-1741.

Zabel, R.W., M.D. Scheuerell, M.M. McClure and J.G. Williams. 2006. The interplay between climate variability and density dependence in the population viability of Chinook salmon. Conservation Biology. February 2006.



Economic Analysis of the Columbia River Basin Water Mitigation Program

Prepared for the:

Columbia River Inter-Tribal Fish Commission
Portland, Oregon 97232

Prepared by:

Resource Dimensions, LLP
7414 30th Street NW
Gig Harbor, WA 98335

DRAFT

28 September 2006

This investigation, analysis, and subsequent report are subject to important conditions and assumptions that affect the findings and conclusions. Applicable data gaps, or lack of supporting documentation, are identified throughout the report. The reader should review all limiting conditions and assumptions contained in this report before utilizing or relying upon the conclusions and findings.

Resource Dimensions team *(in alphabetical order)*:
Julie Ann Gustanski, Ph.D.[1]
E. Ariel Bergmann, Ph.D.
Eva Gibson-Weaver, M.S.

[1] Corresponding author and principal investigator.

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Executive Summary

This analysis of the Washington state's water rights mitigation program for the Columbia River as it relates to particular water rights issues currently under legal review has been prepared for the Columbia Inter-Tribal Fish Commission (CRITFC) and member tribes involved in the appeal of several water rights granted to irrigators for surface waters of the Columbia River. The analysis evaluates key questions and estimates the economic impacts in terms of mitigation potential that can be acquired within the Columbia River basin in both normal and low water years under several alternative policy or program actions versus the status quo alternative of $10 PAF. Comparative, statistical, and economic analyses are used.

Resource Dimensions was commissioned in February 2006 to evaluate the primary question: "Is the fee level proposed for new water diversions within the Columbia River basin sufficient to assure that adequate mitigation funds will be available to protect instream requirements during a dry year at any given point into the future?" Addressing the multiple complex layers influenced by history, state and federal legislation, and the institutional setting of the proposed mitigation program required an approach that could objectively address both this question, as well as those embedded in related issues such as:

- Assessment of benefits generated by direct revenues
- Legal and fiduciary responsibility of the State related to development of an equitable water rights mitigation program for the Columbia River
- Potential of the mitigation fund to realize present income and enhance the resource base for perpetual revenue generation.
- Assessment of costs accrued beyond direct management costs

Because there is insufficient and very limited information on water prices in Washington state this analysis takes a benefits transfer approach its investigation and analysis to calculate the potential mitigation for each policy alternative (e.g. the quantity of water that could be purchased in future years). The first value is the accumulated value of the mitigation trust fund based on projected annual deposits to the fund and the projected investment yield. The second value is the future cost of water. Future water acquisition cost alternatives are presented to aid in evaluating the impacts under the potential scenarios.

The Big Picture

Traversing two countries, including seven states and one Canadian province; thirteen dams on its mainstem and over 400 on its tributaries, the Columbia River Basin is a tremendously important resource. As a result, the management of the Columbia River is among the most jurisdictionally complex in North America; involving international agreements, U.S. and Canadian federal policies, state, provincial and tribal government regulations, and numerous communities.

Tribal rights in the Columbia Basin extend beyond reservation boundaries. In the various Treaties of 1855 between the Columbian Basin treaty tribes and the U.S. government the tribes ceded about 40-million acres of land to the United States, but the tribes reserved rights to hunt, fish, gather wild subsistence foods, and pasture livestock on ceded lands. These rights have been

confirmed repeatedly in the courts, and subsequent interpretations of the treaties have recognized a trust responsibility between tribes and various governmental units. These responsibilities require that the government ensure tribal lands and resources are protected and enhanced; this includes management of water resource to maintain harvestable stocks of anadromous fish. Thus, water rights are of critical importance.

Section 2 gives a general synopsis of the issues relative to tribal reserved rights (e.g. economic, social/cultural, environmental) as they broadly relate to the issuance of new water rights.

Section 3, presents three policy alternatives to the $10 PAF mitigation fee proposed by the State. The alternative mitigation fees were determined by an analysis of publicly available information on water leases, purchases and grants for improving water resource management. The price information is not market based, but is derived from select available acquisition data. These prices represent expenditures based on fiduciary management of public funds, not profit maximizing as by a commercial firm, and are therefore deem to be superior for this study. Water acquisitions under the mitigation fee and trust fund program will operate under the same standards. The alternatives presented in Section 3 are used in conducting Section 4 analyses.

The Analysis

Section 4 presents the findings of the economic analysis on mitigation fund impacts given various water acquisition costs under proposed policy alternatives. Details of the analysis aid evaluation of various consequences of three policy-based fee alternatives versus the status quo.

Given the limited availability of data pertaining to water prices in Washington state, in particular that information relevant to dry year lease transactions, the analysis herein uses a benefits transfer approach to estimate: 1) the future accumulated value of the trust fund based on projected annual deposits and the projected investment yield; and 2) the future cost of water.

To provide some insight and assist in evaluating the potential impacts under different future conditions, three future water acquisition cost (AC) alternatives are presented:

- AC1 at $30 PAF provides for short-term lease of water for instream use during non-drought periods;
- AC2 at $132 PAF provides for short-term lease of water for instream use during drought periods, and;
- AC3 at $1,450 provides for purchase of water rights for instream use.

Similarly, four policy-based alternative (PA) mitigation fees are used to estimate the future value of the mitigation trust fund, and include:

- PA1 – (status quo alternative) uses the $10 PAF value proposed by the State.
- PA2 – uses a proposed annual mitigation fee of $20 PAF. This value represents a mid-point value between the Alternative 1 and Alternative 3.
- PA3 – uses a proposed annual mitigation fee of $30 PAF. This value results from analysis of water lease transactions for instream flow mitigation during 2002-2005 (Appendix A).
- PA 4 – uses a proposed mitigation fee of $75 PAF for permanent acquisition of water rights. This value was derived through analysis of two distinct government actions discussed in Section 3.1.5.

Each alternative relies on the availability of replacement water, either by purchase or lease within the Basin.

In Section 5 conclusions about the mitigation program and recommendations to address potential risks and uncertainties in the program are put forth.

The principle risks and uncertainties identified are:

- The length of time that the fund will have to accumulate funds. This relates directly to predictions of what future drought cycles will occur in Washington state.
- The duration and intensity of the future droughts. This determines the quantity of water that will be needed for mitigation and over what time interval.
- The availability of water for acquisitions by the mitigation fund.
- The management of the fund to assure accumulation for drought periods.

Recommendations to address these risks and uncertainties include:

- The mitigation fee be set at $30 PAF until it can be demonstrated that a lower fee level will provide sufficient funds for mitigation during a drought.
- A systematic review and adjustment of mitigation fees to meet the expected demands for water in a drought.
- Commitment by the State to supplement the trust fund if accumulated fees prove inadequate during a drought cycle.
- A first right of purchase should be given to the mitigation program during periods of drought.
- Further study and research are needed to ensure sound management of the program. Much of the research and studies to date appear to be ex-post to support the predetermined $10 PAF fee.

List of Acronyms

AF	Acre-foot; the volume of water it takes to cover an acre of ground to a depth of one foot, or 325,851 gallons.
BMP	best management practices
BT	Benefits-transfer; an economics approach used to assess values in a particular case or setting based on information learned from other studies removed by time and/or place.
CBWTP	Columbia Basin Water Transfer Partnership
CFS	Cubic foot of water per second of time; one CFS is equal to the discharge of a stream of rectangular cross section, 1 foot wide and 1 foot deep, flowing water an average velocity of 1 foot per second.
CRITFC	Columbia River Inter-Tribal Fish Commission
CSRIA	Columbia-Snake River Irrigators Association
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
DNR	Washington State Department of Natural Resources
Ecology	Washington State Department of Ecology
FY	Fiscal year
IEGP	Irrigation Efficiency Grant Program
KID	Kennewick Irrigation District
KPHD	Kennewick Public Hospital District
PAF	Per Acre Foot; see acre foot (AF) above.
WOFM	Washington State Office of Financial Management
WWT	Washington Water Trust

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Section 1: Introduction

1.1 Scope & Limitations

This analysis of the Washington State Department of Ecology (Ecology) water rights mitigation program for the Columbia River has been prepared for the Columbia Inter-Tribal Fish Commission (CRITFC) and member tribes involved in the appeal of several water rights granted to irrigators for surface waters of the Columbia River. These include the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), the Confederated Tribes and Bands of the Yakama Nation and the Nez Perce Tribe.

The report specifically estimates the economic impacts in terms of mitigation potential that can be acquired in both normal and low water years under several different alternatives versus the status quo alternative of $10 per-acre foot (PAF) within the Columbia River basin. The $10 PAF measure initially put forth by the Columbia-Snake River Irrigators Association (CSRIA) in its proposed mitigation strategy has long been contested by several parties; including CRITFC and member tribes to the pending appeal, it was adopted by Ecology and later embodied within SB 6581 (the Columbia River Management Plan) which passed into law in February 2006.

As noted in the opening pages of this report, the foregoing analysis and subsequent report are based on certain assumptions and confined by data gaps that may affect both the depth of exploration and our findings. It is incumbent upon the reader to review noted limiting conditions and assumptions contained herein.

1.2 Background

Water is an essential resource, and is often the limiting factor for any social or economic activity in Washington state. This limitation is even more apparent in the eastern Washington.

There are many competing parties and needs for the water that flows through the Columbia River basin (Figure 1.1). The competitors for this limited and scarce resource vary from municipalities that require water for basic human needs, to industrial and commercial firms that use water to produce goods or services, to the wildlife and plants which either thrive or cease to exist depending on water availability, to the Tribes with long established cultural ties and rights to the rivers and its resources, to electric power producers, and the farmers and rancher who grow our food.

Figure 1.1 Columbia River Basin

Source: University of Washington NREL, 2005

There is insufficient reliable water for all the needs and desires of the growing human population to be met, and the needs of existing ecosystems to be supported, let alone for ecosystems to be repaired and returned to a healthier and more robust level. For this reason any new withdrawals of water for out of stream use are likely to be controversial and subject to extensive public and private examination.

Over the last 30 years the state of Washington has instigated numerous policies and laws to address the allocation of water.

In 1980 an instream flow rule for the Columbia River was initiated to curtail water use during low water conditions. Rights to use or withdraw water along the mainstream of the Columbia River can be restricted or stopped if the total amount of water flowing at The Dalles Dam is

forecasted to be below 60 million acre-feet (MAF) between April and September. Water users with junior rights (permits issued after 1980) may be ordered to stop using water at certain times during that period.

In the early 1990's Washington state ordered a moratorium on new water rights being granted for the Columbia and Snake Rivers. This was in response to the Snake River sockeye salmon being listed as an endangered species. The State perceived a need for further research and information to be gathered with regard to appropriate instream flow requirements to address the growing list of endangered fish and wildlife in the river ecologies.

By 1997 the moratorium was lifted following legislative revisions on water rights. These revisions mandated that previous instream flows established in 1980 would no longer be applied to new water rights applications. The new legislation required all water right application be evaluated for possible impacts on fish and existing waters. The Department of Ecology (Ecology), as the lead agency, was ordered to consult with appropriate local, state, tribal and federal agencies in the water permit evaluation process. All new permits were to be subject to instream flow protection or mitigation requirements, determined on a case-by-case basis, through the joint consultation and evaluation process.

Ecology did not issue any new water rights under the revised legislation for several years. Then in 2000, the Columbia-Snake River Irrigators Association (CSRIA), an irrigators' trade group, filed a lawsuit against Ecology seeking a judicial order to require the processing of pending water right applications. The settlement between Ecology and CSRIA called for ten water right applications pending since the 1991 moratorium to be processed. Within the settlement agreement is the first instance in which the State, agreed to one mitigation option; that being a fee of $10 PAF per annum to be paid by the new water permit holder.

Five of the applications have been approved and issued permits. Three of these five permits were issued for non-consumptive use of diverted water.

The Court of Appeals rejected the interlocutory appeal of the Kennewick Irrigation District and other appellants who were the subject of the remaining five permits. *Nez Perce Tribe, Confederated Tribes of the Umatilla Reservation, Confederated Tribes and Bands of the Yakama Nation v. Washington State Department of Ecology.* One contention held by the tribes' is that the mitigation requirement of $10 PAF of diverted water resulting from new water uses to "...meet present and foreseeable future irrigation and municipal water requirements"... is insufficient to offset the long-term impacts on both salmon and their reserved water rights; particularly in a recurrent dry year scenario.

1.3 Purpose

The purpose of this economic analysis is to identify and assess the most appropriate, efficient and effective monetary fees which will be paid by holders of new water permits issued by the State. Within the confines of time and access to reliable data, this analysis will address the question:

> **What level of fees should be levied on new water diversions within the Columbia River basin to assure that sufficient mitigation funds will be available to protect instream requirements in the future?**

Section 2: Mitigation Issues & Impacts

2.1 Overview

This section provides a brief overview of relevant mitigation issues and impacts related to the issuance of new water rights in general, as well as those specifically linked to the permits at issue.

The Columbia's basin extends across the border of two countries, seven states, and hundreds of governmental subdivisions. The geographic area covered is home to thirteen Indian tribes, and eight federal agencies have water-related resource responsibilities in the basin (Blumm and Swift, 1997). The River's multifarious framework embodies various dams, diversions, impoundments, and numerous environmental factors, including the life cycle patterns of Columbia River salmon. The River's salmon populations are managed and protected through an equally complex legal, institutional, and decision-making framework. The blend of jurisdictional intricacies, combined with the concoction of treaties, executive orders, legislation, and court rulings make the Columbia River one of North America's most jurisdictionally complex rivers.

In Washington the right to use water is regulated by state laws founded on the principle of "first in time, first in right." Developed in mining camps and later adapted to agriculture, the doctrine of "prior appropriation" governs water rights in most western states (Getches, 1997). Under the appropriation doctrine, water rights are established by forming the intent to divert water to a beneficial use followed by the installation of a diversion and applying the water to beneficial use. Thompson v. Short (1940).

The state's Water Code requires a person who wants the right to use water to file an application with Ecology (RCW 90.03.250). Ecology must then examine and establish if the proposed use is a "beneficial use" of water, whether the water is available for the proposed use, whether the use of water will injure existing rights to the use of water, and if the use will be in the public interest (RCW 90.03.290). Only if Ecology can answer all questions in the affirmative can a permit be issued. Stempel v. Dept. of Water Resources (1973).

Decisions over permit applications for water withdrawals from the Columbia River involve imprecise calculations and numerous assumptions about river flows, the physiological needs of salmon, and present and future quantities of upstream water use. Beyond this is the recognition that present flows in the Columbia River mainstem may not necessarily accurately reflect current legal allocations. Each of these factors, combined with climate trends and variations, indicate that actual withdrawals may be augmented by water rights not currently being used and water rights applied for but not yet adjudicated. Some water rights holders may go many years without diverting their full entitlement. This is important because unless full rights are extinguished for lack of use, they may emerge as significant withdrawals at some unpredictable future time. Such decisions therefore must respect and weigh an array of imperfectly understood risks.

During periods of water shortage, the oldest water rights are to be satisfied before junior water rights can be satisfied. Essential to the case at hand is the fact that, in addition to state water rights, the U.S. Supreme Court has long recognized that federal and tribal water rights also exist and must be satisfied in the water priority system.

2.2 Reservation of Tribal Rights

Tribal water rights are governed by a body of federal law that acknowledges unique property and sovereignty rights held by the tribes over water both on and off reservation. Unlike state law water rights, no diversion is necessary to establish a priority date for a federal reserved water right. The great value of tribal water rights, particularly during times of increasing water scarcity, has brought these rights under increasing challenges in the courts and in political arenas

In 1855, the U.S. government entered in separate treaties with the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes and Bands of the Yakama Nation, and the Nez Perce Tribe; appellants in the appeal mentioned in Section 1.2, as well as the Confederated Tribes of Warm Springs. The tribes also reserved rights to fish in their 1855 treaties with the United States, as much of their existence (i.e. cultural, spiritual, economic and nourishment) centered on the River's vast water resources, and salmon stocks. This "fishing clause" is an important element to the Columbia River tribes' 1855 treaties and the tribes' rights to take fish and regulate fishery resources have been clearly upheld in numerous legal cases over time.

Section 3: Policy Alternatives

3.1 Introduction to Mitigation Policy Study Alternatives

The four policy-based alternatives outlined below represent potential mitigation fees that could be assigned to future water diversions within the Columbia River basin for new water permits issued by the State.

3.1.1 Methodology

The commercial market for water is an inadequate source of information for any meaningful analysis of water prices. This is the result of too few transactions in the marketplace and insufficient details being revealed to the public by private parties.

Although extremely limited, the best available information on water transactions comes from various government agencies and non-profit organizations, such as the Washington Water Trust. However, these institutions operate under different principles and financial objectives than private parties. Prices reported by these institutions reflect their fiduciary responsibility to pursue good value for the public funds expended. They do not use profit maximizing decision criteria to determine the value of water.

Given the information scarcity about commercial transfers, alternative water transactions and programs have been included in the estimation of PAF water values.

In the following sections, four policy-based alternative (PA) mitigation fees are proposed. Each is described in terms of an annual fee to be paid for new water rights and terms of a purchase price. Each scenario relies on the availability of replacement water (required due to the allocation of the permits), either by purchase or lease within the Basin.

The values for the four alternatives are dependent on the discount rate applied in present value calculations. The discount rate is the value used to determine the equivalent monetary value today of future cash flows from a project or resource.

The discount rate reflects the time preference of money to an individual or firm. Time preference relates to the subjective perception that money received this year is normally deemed to be more valuable than the same amount of money received next year. Commercial enterprises typically use discount rates that are in excess of 15% to 20%; higher discount rates indicate greater value of money received in the present compared to the future. This is to be expected from private profit making firms.

Governments often use low discount rates because money received this year is not necessarily deemed to be more valuable than the amounts received in future years. This lower rate is partly motivated by the long term nature of governments providing for future generations.

For this analysis, we use a 5.25% discount rate for public moneys and 15% for private commercial money.

3.1.2 Alternative 1: Status Quo – Proposed $10 Per Acre Foot

The status quo alternative (Alternative 1) uses the $10 PAF value proposed by the State. Under this alternative, there are no substantive program policy changes or modifications that would significantly affect revenue generation. All new water rights issued by the State would carry an obligation on the holder to pay an annual fee into a mitigation fund.

The commercial present value of a permanent $10 PAF annual payment with a 15% discount rate is $66.67. This can be interpreted as the one time payment a water owner would need to receive in exchange for permanently transferring an acre-foot of water to another water user. That is, the business sees no financial difference between selling the water for $10 PAF a year or a $66.67 lump sum.

The government's present value of a permanent $10 PAF annual payment into the mitigation fund at 5.25% discount rate is $190.48. This can be interpreted as the one time payment the government would be willing to receive for each acre-foot of new water right issued in replacement of the $10 PAF annual payment.

3.1.3 Alternative 2: $20 Per Acre Foot

Alternative 2 is a proposed mitigation fee of $20 PAF paid annually. This value is included as it represents a mid-point intervening value between the Alternative 1 and Alternative 3. Beyond the mitigation fee increase there are no substantive program policy changes or modifications that would significantly affect revenue generation. All new water rights issued by the State would carry an obligation on the holder to pay an annual fee into a mitigation fund.

The commercial present value of a permanent $20 PAF annual payment with a 15% discount rate is $133.33. This can be interpreted as the one time payment a water owner would need to receive to permanently transfer an acre-foot of water to another water user. The business sees no financial difference between selling the water for $20 PAF a year or a $133.33 lump sum.

The government's present value of a permanent $20 PAF annual payment into the mitigation fund at 5.25% discount rate is $380.85. This can be interpreted as the one time payment the government would be willing to receive for each acre-foot of new water right issued in replacement of the $20 PAF annual payment.

3.1.4 Alternative 3: $30 Per Acre Foot

Alternative 3 is a proposed mitigation fee of $30 PAF annually. There are no substantive program policy changes or modifications, beyond the mitigation fee increase, that would significantly affect revenue generation. All new water rights issued by the State would carry an obligation on the holder to pay an annual fee into a mitigation fund.

The $30 PAF value was derived from an analysis of lease transactions initiated for instream flow mitigation between 2000 and2005 (Appendices A and B). The lease data comes from the Columbia Basin Water Transfer Partnership (CBWTP) and the Washington Water Trust (WWT); the principle parties for leasing and holding the water rights in trust, respectively.

Transactions reported by CBWTP occurred between 2002 and 2005; a period not classified as drought years. Therefore, the $30 PAF value is influenced by water leased by a public agency for public benefits in markets functioning in non-drought conditions.

Fourteen lease transactions publicly reported by the CBWTP had sufficiently complete information for use in this analysis (Appendix B). All were for water that would be provided during all or part of the dry season in Washington State, May to September. All water rights were leased to supplement instream water flow and were transferred to and held by the WWT.

The year of each transaction was not reported by the CBWTP, therefore it is not possible to adjust the nominal prices (actual price at the time of transaction) to real prices (prices adjusted for inflation) to enable price comparison over time). Thus, the prices have not been adjusted for inflation. However, the transactions reported did occur over a short time period 2002-2005; the first three years of CBWTP operations. The single result of not using adjusted prices is to make the estimated value conservative (lower) than it might be otherwise.

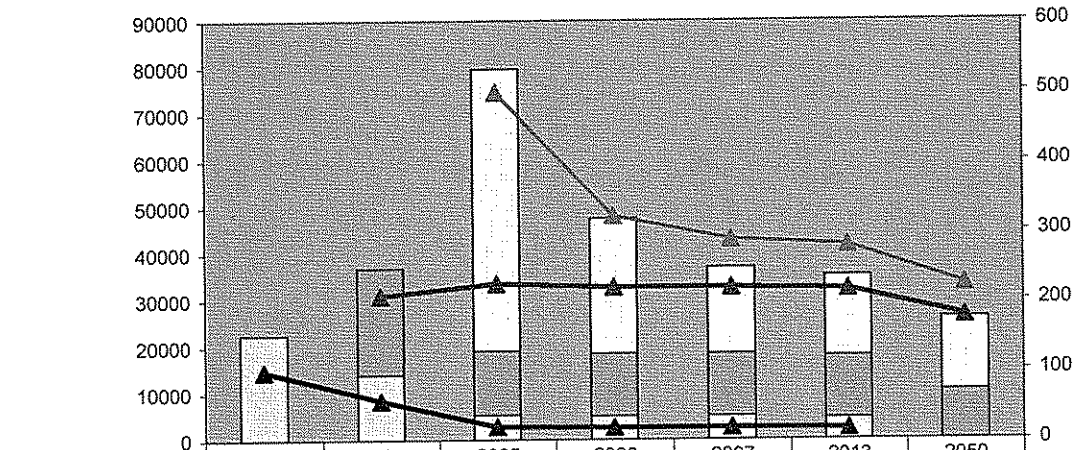
The two key statistical values that are import to this study are the mean and the range of prices paid for water.

- The average (mean) price PAF is $30.17.
- Water prices ranged from a low of $13.68 to a high of $36.64.
  The lowest price paid appears to be an anomaly as the next lowest price is $27.00 PAF (three transactions at this price). Ten transactions were recorded at over $30 PAF.
- The weighted average of the 14 transactions is $31.41 PAF.

A weighted average takes into account the quantity of water that is being transacted, or contracted for, at the different prices. It is useful to see if the quantity of transactions has a significant effect on the average price paid. The weighted average price is 4% higher than the average price which indicates that the sizes of the transactions do influence the PAF price.

These transactions suggest a representative price of about $30 PAF for leasing water to supplement instream water flow during times of normal precipitation. While higher than either the $10 PAF or $20 PAF alternatives presented above, the authors believe this value is conservative and low in that it represents recent historical values that have been paid by a quasi-governmental agency for water leases.

Figure 2.1 Columbia Basin Water Transfer Partnership Instream Acquisitions 2003-05



	2003	2004	2005	2006	2007	2013	2050
FY'05 Duty (AF)			60548.135	29034.08	18473.69	17253.78	15652.33
FY'04 Duty (AF)		22844.371	13755.44	13431.74	13431.74	13321.94	10567.3
FY'03 Duty (AF)	22641.28	14057.02	5398.76	5103.08	5103.08	4673.6	
FY'05 Rate (cfs)			274.27	102.46	68.79	63.22	46.22
FY'04 Rate (cfs)		150.149778	204.709778	200.929778	200.929778	199.855778	177.446778
FY'03 Rate (cfs)	98.621	56.52	19.12	17.54	17.54	15.86	

Source: CBWTP http://cbwtp.org/jsp/cbwtp/library/documents/CumulativeWater03-05.doc

The commercial present value of a permanent $30 PAF annual payment with a 15% discount rate is $200. This can be interpreted as the one time payment a water owner would need to receive to permanently transfer an acre-foot of water to another water user. The business sees no financial difference between selling the water for $30 PAF a year or a $200 lump sum.

The government present value of a permanent $30 PAF annual payment into the mitigation fund at 5.25% discount rate is $571.43. This can be interpreted as the one time payment the government would be willing to receive for each acre-foot of new water right issued in replacement of the $30 PAF annual payment.

3.1.5 Alternative 4: $75 Per Acre Foot (Permanent Acquisition)

Alternative 4 is a proposed mitigation fee of $75 PAF per annum. There are no substantive program policy changes or modifications, beyond the mitigation fee increase, that would significantly affect revenue generation. All new water rights issued by the State would carry an obligation on the holder to pay an annual fee into a mitigation fund.

The $75 PAF value was derived from an analysis of two distinct government actions described below.

Early in 2006 the City of Olympia, Washington, and other local governments joined in condemnation proceedings to acquire the water rights from the owner of a closed brewery. The water rights were not being beneficially used and were threatened to become relinquished.

Condemnation proceedings were settled by the parties prior to a court hearing. The mutually agreed compensation price was $1,750 PAF of water and other non-monetary considerations that have no bearing on this analysis. Rights to over 2,000 AF of water were transferred by this agreement. The water was converted to municipal service use; one of the highest possible use values.

In Alternatives 1 and 2 the annual payments were converted into equivalent lump sum present values. For Alternative 4, the reverse calculation is made to determine the annual fee payment. Thus, $92 PAF paid annually in perpetuity is equivalent to the negotiated one time payment of $1,750 PAF. This value assumes a discount rate of 5.25% per year.

From the perspective of a commercial business the equivalent PAF price required is $262.50 PAF paid annually. This value assumes a discount rate of 15% per year. The business sees itself as being compensated at this price for each AF.

The state's Irrigation Efficiency Grant Program (IEGP) was established to generate water savings (reduced consumptive use) thus allowing more water to remain instream. Funds are distributed to farmers with an objective to improve water delivery systems (piping, canals and ditches) or on-farm system efficiencies (replacing flood irrigation with center pivot systems).

Conservation Districts, responsible for distributing the funds, use a critical threshold value of $400,000 per one cubic foot per second (CFS) of water savings to determine if the project is sufficiently effective to grant public funds to a private individual or commercial association (farmers or canal associations). Projects that return less than one CFS per $400,000 are not funded.

One CFS of water for the duration of the growing season is equal to 280 AF of water per growing season. See Table 3.1. If the 280 AF of water per $400,000 is interpreted to be an acquisition, the State is paying $1,428.60 PAF for water to remain instream.

An equivalent lease price would be $75 PAF per year, in perpetuity. As before, this value assumes a discount rate of 5.25% per year.

Table 3.1 Water Flow Conversion – Cubic Feet per Second (CFS) to Acre-Feet per Growing Season[1]

Water Flow Measure	Conversion Ratio									
CFS	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
AF per season	28	56	84	112	140	168	196	224	252	280
CFS	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2
AF per season	308	336	364	392	420	448	476	504	532	560
CFS	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3
AF per season	588	616	644	672	700	728	756	784	812	840

Note: Growing season is May 1 to September 15.

Source: Resource Dimensions, 2006

This analysis recommends and will use a price of $75 PAF annual fee value, not the alternative higher value of $92 PAF. This lower value represents water that is being converted from irrigation and agriculture to instream maintenance use, the same objective as the mitigation fund.

3.2 Present Value of Alternative Mitigation Fees

The implications of the various mitigation fees associated with Alternatives 1 through 4 are important indicators of actual and perceived value of water. The present value of a future income stream can be converted into an equivalent lump sum cash payment received today.

Assuming a commercial enterprise, like a farm, has a discount rate of 15%, then paying $10 PAF in perpetuity for uninterruptible water rights implies that the farmer values the water at an equivalent lump sum payment to the state of $67 PAF today. A higher discount rate would drive this $67 value for water even lower, while a higher annual payment would increase the value. This increase in value can be seen in Table 3.2, which list the present value of the four alternative mitigation fees. Both commercial and governmental discount rates are given.

Governments often use discount rates that range from 1% to 6%. These lower rates reflect the long time horizons over which a government values assets within their jurisdiction. In other words, a benefit derived 20, 50 or 100 years into the future may be of similar value as it would be today. This can be compared to businesses that operate using much shorter time horizons, typically less than 20 years. For them benefits (profits) earned today are clearly more valuable and important then benefits (profits) earned in 5 or 10 years, let alone 50 years hence.

Table 3.2 Present Value of Future Mitigation Fees

Annual Mitigation Fee ($ per acre-foot)	Commercial Present Value (15% discount rate)	Governement Present Value (5.25% discount rate)
10	$66.67	$190.48
20	$133.33	$380.95
30	$200.00	$571.43
75	$500.00	$1,428.57

Source: Resource Dimensions, 2006

Section 4: Assessing the Value of the Resource

4.1 Introduction

The potential mitigation for each policy alternative (e.g. the quantity of water that could be purchased in future years) is addressed and analyzed in this section.

Because there is insufficient and very limited information on water prices in Washington State, this analysis uses a benefits transfer approach to estimate the future quantities. Two values are used to calculate the quantity. The first value is the accumulated value of the trust fund based on projected annual deposits and the projected investment yield. The second value is the future cost of water. In Section 4.3 three future water acquisition cost alternatives are presented to assist in evaluating the impacts under three potential scenarios.

4.2 Approach

In a perfect world this analysis would have information on all water transactions within the boundaries of the Columbia basin, both private and public, for at least the last 50 years. It would also have access to knowledge of the intended uses of the water in the future. If this data existed less controversy would also exist over the risk of the mitigation trust fund being able to provide financial resource for drought mitigation in the future.

While much of this information does exist, the cost, in terms of time and money make it unlikely that it will ever be fully collected into a usable form. Thus, we must operate in the alternative. The analysis will rely on available information to estimate the quantity of water that may be purchased into the future to mitigate instream flows in drought years within the basin—and the potential cost of that quantity of water.

The economic practice of taking information or data from other studies conducted in different geographic regions and applying it to similar contextual situations is called the benefits transfer (BT) method. This process is used herein to support the rationale for alternative mitigation fees and to estimate different potential costs of water acquisition. The values applied in the analysis were selected based on the ability to verify data, adaptability, and professional judgment as to reasonableness within the range of industry standards.

The advantages of this approach are several; most importantly here is that it is less time consuming, and thus far less expensive than a study employing site-specific original research. To help lessen the disadvantages for the purposes of this analysis, we incorporate input from consultations with several leading researchers, various Ecology, WWT and CBWTP personnel. The information gained from these experts provide important insights on the best approach of applying economic values measured elsewhere to the Columbia basin, as well as possible restrictions of using this method. Additionally, these interviews helped to ascertain the attributes and values for use in establishing the alternatives used in the analysis.

Many assumptions were necessarily made in this study. The authors have tried to explicitly state those assumptions throughout this report to clarify the analysis and identify those issues that may have significant bearing on the findings.

Determination of the full economic value of water from the myriad of uses that it is currently put to or could be applied to in the future is beyond the scope of this study. Thus, it is important to note that the method used almost certainly underestimates the full range of economic values specific to water as a resource. Various economic studies throughout the world have attempted this task, **however, the issue at hand is oriented to the practical matter of estimating the quantity of water that a mitigation trust fund may provide under various cost scenarios during drought conditions in Washington state.**

4.2.1 Benefits Transfer

The benefits-transfer (BT) method is used to estimate economic values for a potential program, or a proposed activity, by transferring available information from another location and/or context. BT is often used when it is too expensive and/or there is too little time available to conduct an original valuation study, yet some measure of costs and benefits is needed.

It is important to note that the BT approach relies on the accuracy of the initial valuation study. Thus, the basic goal of benefit transfer is to estimate benefits for one context by adapting an estimate of benefits from some other context.

4.2.1.1 Application of the Benefit-Transfer Method

Step 1:

The first step is to identify existing studies or values that can be used for the transfer. In this case, we first sought to identify studies/market prices that value the use of water in the specific stream, river or reach involved. Given that a certain proportion of the information was not publicly available for this study alternative values provided within transaction records of the WWT and CBWTP were used.

Step 2:

The second step is to decide whether the existing values are transferable. The existing values or studies were evaluated on several criteria, including:

1. Is the resource being valued comparable to the resource valued in the existing study or studies? Some of the factors that determine comparability are the similarity of water uses, both before and after, as well as, the location and substitutability of the water. (Is the water in a different drainage basin? or Is extraction point upstream or downstream?)
2. Are characteristics of the relevant population comparable? For example, are demographics similar between the area where the existing study was conducted and the area being valued? If not, are data available to make adjustments?

Step 3:

Next the quality of studies to be transferred was evaluated. The better the quality of the initial study, the more accurate and useful transfer values are. This requires professional judgment on the part of the researcher.

Step 4:

Finally, using available relevant information, existing/available values were adjusted to better reflect the values for the site under consideration. To the extent necessary, supplemental data and personal interviews with experts from various disciplines was collected.

4.3 Future Cost of Water

This section conforms to steps one and two from Section 4.1. Using data from the WWT, CBWTP and other state agencies or courts, three values are proposed as being reasonable, valid, and supportable by actual economic transactions that have occurred in the past decade in Washington state.

This study uses the following transaction prices in projecting the future cost of acquiring water:

4.3.1 Acquisition Cost 1:

$30 PAF to acquire water by short-term lease. This price is based on the experience of CBWTP leasing water during 2002-2005; a non-drought period. This is the same price as Alternative 3, in Section 3.

4.3.2 Acquisition Cost 2:

$132.00 PAF to acquire water by short-term lease. This value was derived by examining leases initiated by the WWT during drought years at the beginning of the decade.

WWT provided information on ten transactions in which they became holders of water rights in trust during 2000-2001. Seven of the transactions were one year leases for water during the irrigation season of 2001. The following monetary values are adjusted for inflation and represent 2005 dollars.

The average (mean) lease had a PAF price of $131.54.

Water prices ranged from a low of $120.25 to a high of $140.24. The highest value was paid for a lease which ran from April 1 to October 1, 2001. All other leases were limited to the period July1 to October 1, 2001.

The weighted average of the seven leases is $135.70 PAF. A weighted average takes into account the quantity of water that is being transacted, or contracted for, at the different transaction prices. It is a useful measure to see if the quantity of water in any single or set of transactions have a significant effect on the average price paid.

The weighted average price is 3% higher than the average price, which indicates that the quantity of water in any single transaction does influence the PAF price. Larger transactions are paid more. The quantities ranged from 23 to 407.5 AF.

From these WWT transactions, a recommended representative cost for leasing water to supplement instream flow during drought years similar to the 2001 season is $132.00 PAF.

4.3.3 Acquisition Cost 3:

$1,450 PAF to acquire water by purchase or exchange for capital investment grants. This value is based on the indirect costs paid by the State using the IEGP, which is described and analyzed under Alternative 4, in Section 3.

4.3.4 Acquisition Cost Summary

Table 4.1 presents the three water acquisition cost (AC) alternatives used in this analysis. These alternatives represent the baseline market prices, in 2006 dollars, to acquire water for drought mitigation. Estimated acquisition costs for water in future years will be inflation adjusted from these prices.

Table 4.1 Alternative Costs of Water Acquisition ($ per annum/PAF)

Water Acquisition Cost Alternative	Scenario	Value
1	Short-term leasing of water for instream use during **non-drought** periods.	$30 PAF
2	Short-term leasing of water for instream use during **drought** periods.	$132 PAF
3	Purchase of water for instream use.	$1,450 PAF

Source: Resource Dimensions, 2006.

4.4 Usefulness of Economic Impact Information

Understanding the economic impacts of alternative costs of water acquisition and its bearing on the amount of mitigation that could occur during a drought crisis or general instream improvement can serve at least two useful purposes. First and foremost, it can aid government in the development and implementation of appropriately constructed policy tools. Second, it provides policymakers, stakeholders and the public at large with key information needed to evaluate whether the tradeoffs between the economic and social benefits of implementing particular policy measures outweigh the potential adverse environmental effects that are not avoided or fully mitigated.

4.5 What Value or Value Range Should Be Assigned?

The future value of the trust fund and the future acquisition cost of water are fundamental to determining how much mitigation can occur during times of drought crisis or general instream improvement. The estimated future value of the fund for each policy alternative and relative expected costs of water are discussed in the following sections.

4.5.1 Calculating Future Value of Mitigation Trust Fund

The trust fund has three characteristics that will determine its value; the duration of the fund, the interest rates paid on deposits, and the amount and timing of the deposits.

A simple annuity model can be used to estimate the monetary resources that will be available in future drought years for instream flow mitigation. An annuity model assumes the creation of a trust fund. The trust will receive a flow of cash on an annual basis which will be accumulated and invested, allowing the fund to experience compound growth. Compound growth occurs when the interest payment on an investment is retained in the fund so each following year's investment interest is paid on the principle amount, any additional deposits, and the retained interest moneys. The fund will be disbursed at some future time period when a predetermined criterion is met.

The first annuity model presented estimates the value of the "Mitigation Trust Fund" that will be created by the annual payments from the irrevocable transfer of 700,000 AF of water by Washington state.

A growth rate of 2.23% is assumed for the fund. This yield is the reported average for trust funds managed by the Washington State Treasury in 2005. This growth rate represents the trust funds being invested in United States Treasury bonds that are short term in quality, highly liquid, and meet "prudent investor" fiduciary standards. The fund needs to be managed in a manner which allows for significant cash balances to be withdrawn on short notice, less than six months. The short notice criterion is necessary as a result of the risk and uncertainty of sufficient precipitation in Washington state (snow and rain fall). Funds will need to be available to implement mitigation purchases and leases for the dry season if a drought occurs in the winter.

It is assumed that all funds collected from water contracts are invested in the annuity. All fund operation and management expenses are assumed to be paid by other sources, i.e. Washington state or a non-governmental organization. The fund will be diminished if on-going administration expenses are applied to the collected revenues.

Table 4.2 presents the predicted future value of the trust fund over various periods of time for each policy alternative.

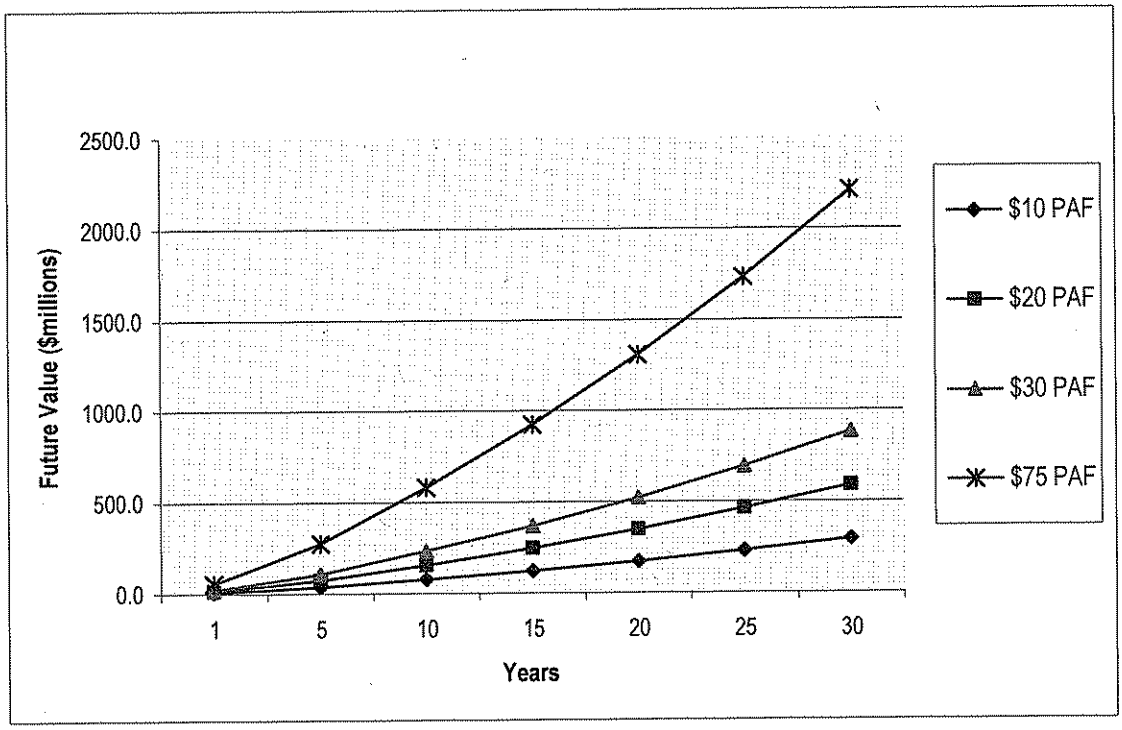
Table 4.2 Predicted Future Values of Trust Fund

Year	Future Value of Trust Fund ($10 PAF)	Future Value of Trust Fund ($20 PAF)	Future Value of Trust Fund ($30 PAF)	Future Value of Trust Fund ($75 PAF)
1	$7.0	$14.0	$21.0	$52.5
5	$36.6	$73.2	$109.8	$274.5
10	$77.5	$154.9	$232.4	$580.9
15	$123.1	$246.2	$369.3	$923.1
20	$174.0	$348.1	$522.1	$1,305.2
25	$230.9	$461.8	$692.8	$1,731.9
30	$294.4	$588.9	$883.3	$2,208.3

Source: Resource Dimensions, 2006

In Figure 4.1 the predicted future values of the trust fund are projected in graphic format to illustrate fund development under each policy alternative.

Figure 4.1 Predicted Future Values of Trust Fund*



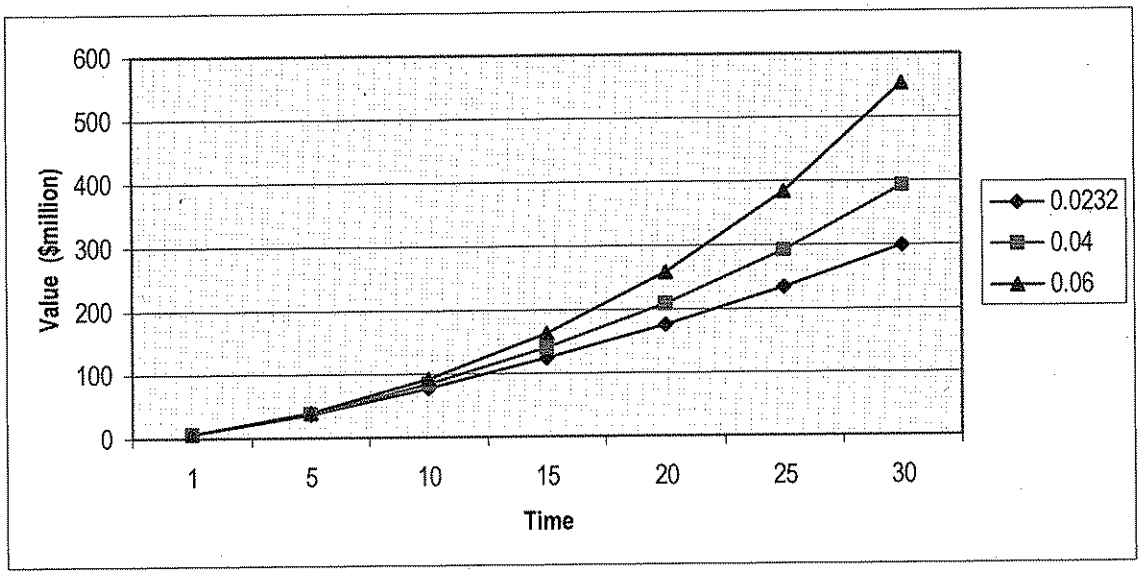
Source: Resource Dimensions, 2006

4.5.1.1 Investment Yields

The yield rate on trust funds managed by Washington state are primarily determined by U.S. Treasury bonds, as these bonds are the dominant investment instrument used by the fund managers. These short-term bonds are heavily influenced by expected inflation rates over the next 1 to 3 years. This is the primary reason for a 2005 yield of only 2.23%. Future yields on the same trust funds are predicted to increase in 2006 to 2007, 3.22% and 3.89% respectively (WOFM, 2006).

Figure 4.2 demonstrates the impact that interest rate changes can have on the mitigation trust fund. The most important result to note is the impact from the annual deposits accumulating for long periods of time and the compounding of the interest paid.

Figure 4.2 Predicted Future Value of Trust at Different Yield Rates



Source: Resource Dimensions, 2006.

4.5.1.2 Drought Cycles

In addition to more frequent drought cycles, climate change models indicate that reduced snowpack will reduce the average annual runoff of the Columbia River at The Dalles by 14.7 % by 2020 and 16 % by 2050 (Hamlet et al. 1997 in Cohen et al. 2000). Thus, there will be less base flow in the river to accommodate existing, much less future needs. Chatters (1991) noted that fish stocks most affected by climate change will be those where the effects of water withdrawals are already problematic.

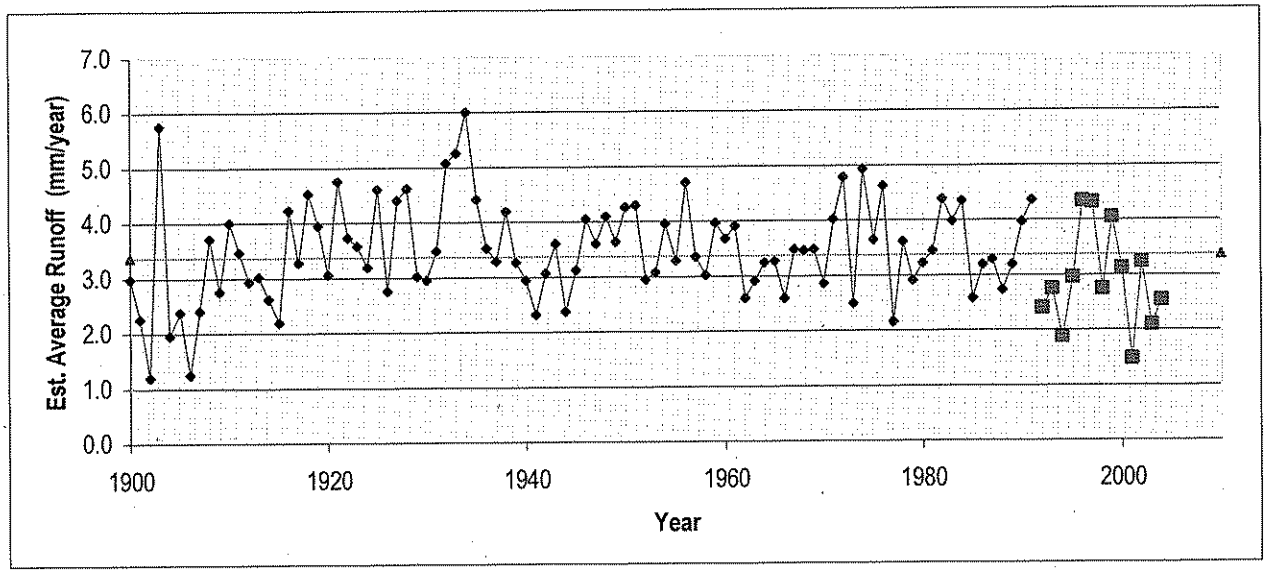
Further, warmer temperatures as a result of climate changes would result in increased growing seasons and generally increased agricultural water consumption. According to an analysis of the reliability of flows for Snake River agriculture, by 2050 agricultural flows would be reduced from 85 % to 70% (Hamlet et al. 1998 in Cohen et al. 2000). Additional new water withdrawals would specify an allowable rate or total quantity of water to be diverted, but the total lost from consumptive use would increase under warmer conditions due to: 1) evaporation and crop evapotransporation and, 2) declines in groundwater levels leading to increased seepage losses from unlined irrigation ditches (Cohen et al. 2000).

The length of time over which the mitigation trust fund can accumulate is an important criterion for it to increase in value. This time dependent increase in value relies on the deposit of annual fees paid and the compound growth rates the trust can experience without having to draw down the fund for mitigation purposes. Therefore, the length of time between occurrences in which the fund must be called on to purchase mitigation is crucial.

In our analyses we find no justification for the use of a 26.7-year drought cycle to predict the interval of time in which funds would be required for mitigation.

Droughts in Washington over the past 50 years tend toward short duration events (see Figure 4.3). However, impending climatic changes may increase the likelihood of multi-year drought events by 2045. Recent projections indicate the number of multi-year droughts could increase by 200 to 400-percent compared to the past 50 years (Gedalof, et al, 2004; Hamlet and Lettermaier, 1999). Therefore, mitigation purchases must be allocated with the understanding that funds may need to provide cover for multiple years, not just a single year.

Figure 4.3 Estimated Average Runoff in Washington State (mm/year)



Notes: Blue (diamonds) are observations from 1900 to 1991. Green (squares) are observations from 1992 to 2004. Red line is the 50 year average runoff (1954 to 2004).

Source: Resource Dimensions, 2006

Data Source: U.S. Geological Survey, Water Watch Program, 2006

There are many definitions of drought, both legal and scientific. Two definitions most relevant to this analysis are agricultural drought (Rosenberg 1979) and hydrologic drought (Yevjevich, Hall, and Salas 1977). The former involves a shortage of precipitation sufficient to adversely affect crop production or range production, while the later involves below average water content in streams, reservoirs, ground-water aquifers, lakes and soils.

The single largest users of water rights are concerned with the first definition; the mitigation fund is concerned with the second.

4.5.2 Calculating Future Costs of Water

Standard analytic procedures encourage the adjusting of transaction prices for expected inflation. This price adjustment is especial necessary when analytic timeframes are long or the inflation rate is high. As example, an inflation rate of 7% will result in prices doubling every 10 years, compared to prices doubling every 28 years if the inflation rate is 2.5%.

This analysis assumes a consistent inflation rate of 2.5% over the next 30 years.

It should be noted that this rate is not a prediction that instream water prices will inflate in a smooth manner over the time frame examined. It is beyond the scope of this analysis to predict future water values. The authors anticipate water prices are to be highly volatile and cyclical in behavior. Several factors support this expectation:

- WWT water leases for 2001-2002 drought held a price of $132 PAF per year, while leases for the following three normal precipitation years were less than 25% of that price;
- As population expansion continues, the need for municipal water grows; municipal demand is more inflexible than water demanded by other users;
- If the market for water rights is developed, as current legislation proposes, prices will become more responsive to droughts and expected/predicted shortages, therefore more volatility will occur;
- Water will increase/decrease in value as the regional economy changes and economic uses for water changes in the future.

4.6 Economic Impacts of Different Mitigation Alternatives

4.6.1 Quantitative Analysis

The following sections provide background and discussion on the analysis conducted to estimate the quantity of water that may be acquired into the future, both in aggregate for the Columbia Basin, and in particular for the rights subject to appeal in the Yakima Basin. This analysis will use the forecast values for the mitigation trust fund, the four policy-based alternative mitigation fees, and the three water acquisition costs developed earlier to quantify the amount of water that may be purchased under different scenarios.

A critical assumption is made in the following quantitative analysis:

The market for water will always have sufficient buyers and sellers for a transaction to occur at a non-discriminatory price in an open competitive market.

This assumption is necessary for two reasons: 1) it is beyond the limits of this analysis to predict if there will be willing sellers of water to the State or non-profit organizations currently operating in the water rights market. There is anecdotal evidence that some traditional water users will not be willing to sell their water rights for the purpose of instream mitigation; 2) the market for water in Washington is very poorly formed and does not meet many of the formal economic criteria for well functioning competitive markets.

4.6.1.1 Estimate of Resource Rights Value in Aggregate for Columbia Basin

There are three applicants for water permits that may be subject to the mitigation permit fees assessed here; the Kennewick Irrigation District (KID), the Kennewick Public Hospital District (KPHD) and Mercer Ranches.

The KPHD application is for 49 CFS instantaneous diversion, which is equal to 13,559 AF per year to irrigate 2,780 acres from March 1 through October 31 each year, plus 392 AF per year for frost protection. The point of diversion would be the Columbia River, downstream from Kennewick.

Mercer Ranches proposes to divert .016 CFS instantaneous, which is equal to 8.7 AF per year for industrial food processing from April 1 through December 31 each year. The point of diversion is from the Columbia River in Klickitat County.

The KID application is for 82 CFS instantaneous diversion, which is equal to 22,610 AF per year for irrigation of 46,737 acres from March 15 through October 15 each year. The point of diversion for this application is from the Columbia River, in Benton County, near the confluence with the Yakima River. This applicant would be required to build a new pump station and piping to connect to the existing irrigation system, which presently draws its water from the Yakima River. In parallel to this permit, plans are being considered to "exchange pumps" so the point of water diversion for KID would be from the Columbia River, not the Yakima River, for the purpose of improving instream flows in the lower Yakima River.

The total quantity of water from the three applicants amounts to 36,570 AF.

4.6.1.1.1 Alternative 1: $10 Per Acre Foot

Under Alternative 1, 36,570 AF of new water permits are issued for diversions from the Columbia River. New permit holders pay a $10 PAF annual fee for uninterruptible rights to the water. Mitigation fees totaling $365,700 per year would be deposited in to a trust fund managed by the State. The following analysis estimates how much water may be acquired to mitigate instream flows during a drought period.

Table 4.3 reports the quantity of mitigation at $10 PAF that may be acquired in different time periods, given duration of trust fund operation. These estimates are based on all funds being expended on a single acquisition category of the six that are given. However, any combination of acquisitions may be attempted.

Table 4.3 Estimated Mitigation (AF) at $10 PAF

Year	Leased Water $30 PAF (Not adjusted)	Leased Water $30 PAF (Inflation adjusted)	Leased Water $132 PAF (Not adjusted)	Leased Water $132 PAF (Inflation adjusted)	Purchased Water $1,450 PAF (Not adjusted)	Purchased Water $1,450 PAF (Inflation adjusted)
1	12,190	11,893	2,770	2,703	252	246
5	63,730	56,328	14,484	12,802	1,319	1,165
10	134,889	105,375	30,657	23,949	2,791	2,180
15	214,345	147,998	48,715	33,636	4,435	3,062
20	303,064	184,951	68,878	42,034	6,270	3,827
25	402,126	216,903	91,392	49,296	8,320	4,488
26.7	438,374	208,992	99,631	47,498	9,070	4,324
30	512,738	244,444	116,531	55,555	10,608	5,057

Source: Resource Dimensions, 2006

The quantity of mitigation that may be leased or purchased by the fund is dependent on the period of time between drought occurrences (frequency). The 26.7-year cycle is described here but alternative cycles should also be considered and the relevant mitigation quantities.

The amount of leased water that could be acquired by the fund ranges from a high of 438,374 AF for water leased with **no price inflation** during the next 26.7-years (if available at non-drought prices) to a low of 47,498 AF of water that experiences a 2.5% annual inflation rate, based on 2001 drought prices.

Acquisition of permanent or very long term water rights through purchase or BMP grant schemes may provide a maximum of 9,070 AF of water in 26.7-years, if no price inflation occurs, to a low of 4,324 AF if BMP technology inflation is limited to 2.5%.

4.6.1.1.2 Alternative 2: $20 Per Acre Foot

As in Alternative 1, the total new water permits issued for diversions from the Columbia River are 36,570 AF. Under Alternative 2, new permit holders pay a $20 PAF annual fee for uninterruptible rights to the water. Mitigation fees totaling $731,400 per year would be deposited in to a trust fund managed by the State. The analysis shown in Table 4.4 estimates how much water may be acquired to mitigate instream flows during a drought period at $20 PAF in different time periods, based on duration of trust fund operation.

Table 4.4 Estimated Mitigation (AF) at $20 PAF

Year	Leased Water $30 PAF (Not adjusted)	Leased Water $30 PAF (Inflation adjusted)	Leased Water $132 PAF (Not adjusted)	Leased Water $132 PAF (Inflation adjusted)	Purchased Water $1,450 PAF (Not adjusted)	Purchased Water $1,450 PAF (Inflation adjusted)
1	24,380	23,785	5,541	5,406	504	492
5	127,459	112,655	28,968	25,604	2,637	2,331
10	269,779	210,751	61,313	47,898	5,582	4,360
15	428,690	295,996	97,430	67,272	8,869	6,124
20	606,128	369,902	137,756	84,069	12,541	7,653
25	804,253	433,806	182,785	98,592	16,640	8,975
26.7	876,748	417,983	199,261	94,996	18,140	8,648
30	1,025,476	488,888	233,063	111,111	21,217	10,115

Note: Quantities shown are based on all funds being expended on a single acquisition category of the six presented. However, any combination of acquisitions may be attempted.

Source: Resource Dimensions, 2006

As stated elsewhere within this report, the quantity of mitigation that may be leased or purchased by the fund is dependent on the period of time between drought occurrences. Impacts relative to the 26.7-year cycle is described here but alternative cycles should be considered together with their related mitigation quantities.

The amount of leased water that could be acquired by the fund ranges from a high of 876,748 AF for water leased with **no price inflation** during the next 26.7-years (if available at non-

drought prices) to a low of 94,996 AF of water that experiences a 2.5% annual inflation rate, based on 2001 drought prices.

Acquisition of permanent or very long term water rights through purchase or BMP grant schemes may provide a maximum of 18,140 AF of water in 26.7-years, if no price inflation occurs, to a low of 8,648 AF if BMP technology inflation is limited to 2.5%.

4.6.1.1.3 Alternative 3: $30 Per Acre Foot

As in Alternative 1 above, the total new water permits issued for diversions from the Columbia River are 36,570 AF. Under Alternative 3, new permit holders pay a $30 PAF annual fee for uninterruptible rights to the water. Mitigation fees totaling $1.09 million per year would be deposited in to a trust fund managed by the State. The analysis shown in Table 4.5 estimates how much water may be acquired to mitigate instream flows during a drought period at $30 PAF in different time periods, based on duration of trust fund operation.

Table 4.5 Estimated Mitigation (AF) at $30 PAF

Year	Leased Water $30 PAF (Not adjusted)	Leased Water $30 PAF (Inflation adjusted)	Leased Water $132 PAF (Not adjusted)	Leased Water $132 PAF (Inflation adjusted)	Purchased Water $1,450 PAF (Not adjusted)	Purchased Water $1,450 PAF (Inflation adjusted)
1	36,570	35,678	8,311	8,109	757	738
5	191,189	168,983	43,452	38,405	3,956	3,496
10	404,668	316,126	91,970	71,847	8,372	6,541
15	643,035	443,994	146,144	100,908	13,304	9,186
20	909,192	554,854	206,635	126,103	18,811	11,480
25	1,206,379	650,710	274,177	147,889	24,960	13,463
26.7	1,315,123	626,975	298,892	142,494	27,209	12,972
30	1,538,214	733,332	349,594	166,666	31,825	15,172

Note: Quantities shown are based on all funds being expended on a single acquisition category of the six presented. However, any combination of acquisitions may be attempted.

Source: Resource Dimensions, 2006

The quantity of mitigation that may be leased or purchased by the fund is dependent on the period of time between drought occurrences (frequency). The 26.7-year cycle is described here but alternative cycles should also be considered and the relevant mitigation quantities.

The amount of leased water that could be acquired by the fund ranges from a high of 1.31 MAF for water leased with **no price inflation** during the next 26.7-years (if available at non-drought prices) to a low of 142,494 AF of water that experiences a 2.5% annual inflation rate, based on 2001 drought prices.

Acquisition of permanent or very long term water rights through purchase or BMP grant schemes may provide a maximum of 27,209 AF of water in 26.7-years, if no price inflation occurs, to a low of 12,972 AF if BMP technology inflation is limited to 2.5%.

4.6.1.1.4 Alternative 4: Permanent Acquisition

As in Alternative 1 above the total new water permits issued for diversions from the Columbia River are 36,570 AF. Under Alternative 4, new permit holders pay a $75 PAF annual fee for uninterruptible permanent rights to the water. Mitigation fees totaling $2,442,750 per year would be deposited in to a trust fund managed by the State. The analysis shown in Table 4.6 estimates how much water may be acquired to mitigate instream flows during a drought period at $75 PAF in different time periods, based on duration of trust fund operation.

Table 4.6 Estimated Mitigation (AF) at $75 PAF

Year	Leased Water $30 PAF (Not adjusted)	Leased Water $30 PAF (Inflation adjusted)	Leased Water $132 PAF (Not adjusted)	Leased Water $132 PAF (Inflation adjusted)	Purchased Water $1,450 PAF (Not adjusted)	Purchased Water $1,450 PAF (Inflation adjusted)
1	81,425	79,439	18,506	18,054	1,685	1,644
5	425,692	376,250	96,748	85,511	8,807	7,784
10	901,014	703,871	204,776	159,971	18,642	14,563
15	1,431,751	988,575	325,398	224,676	29,622	20,453
20	2,024,364	1,235,410	460,083	280,775	41,883	25,560
25	2,686,066	1,448,839	610,470	329,282	55,574	29,976
26.7	2,928,189	1,395,993	665,497	317,271	60,583	28,883
30	3,424,914	1,632,803	778,390	371,092	70,860	33,782

Note: Quantities shown are based on all funds being expended on a single acquisition category of the six presented. However, any combination of acquisitions may be attempted.

Source: Resource Dimensions, 2006

The quantity of mitigation that may be leased or purchased by the fund is dependent on the period of time between drought occurrences (frequency). The 26.7-year cycle is described here but alternative cycles should also be considered and the relevant mitigation quantities.

The amount of leased water that could be acquired by the fund ranges from a high of 2.9 MAF for water leased with **no price inflation** during the next 26.7-years (if available at non-drought prices) to a low of 317,271 AF of water that experiences a 2.5% annual inflation rate, based on 2001 drought prices.

Acquisition of permanent or very long term water rights through purchase or BMP grant schemes may provide a maximum of 60,583 AF of water in 26.7-years, if no price inflation occurs, to a low of 28,883 AF if BMP technology inflation is limited to 2.5%.

4.6.2 How Much Mitigation Can Be Bought?

4.6.2.1 Alternative 1: Status Quo – $10 Per Acre Foot

Under Alternative 1, 700,000 AF of new water permits are issued. New permit holders pay a $10 PAF annual fee for uninterruptible rights to the water. In this scenario, total fees of $7-million would be deposited in to a trust fund managed by the State. The following analysis estimates how much water may be acquired to mitigate instream flows during a drought period.

4.6.2.1.1 Estimated 26.7-year Cycle

If the assumptions in Section 4.5.1 are met, the future value of the mitigation trust fund would be worth $251.7 million at the 26.7-year interval.

The amount of leased water that could be acquired by the fund ranges from a high of 8.39 MAF for water leased with **no price inflation** during the next 26.7-years (if available at non-drought prices) to a low of 0.99 MAF of water that experiences a 2.5% annual inflation rate, based on 2001 drought prices. See Table 4.3.

Acquisition of permanent or very long term water rights through purchase or BMP grant schemes may provide a maximum of 170,000 AF of water in 26.7-years, if no price inflation occurs, to a low of 90,000 AF if BMP technology inflation is limited to 2.5%.

These estimates are based on all funds being expended on a single acquisition category of the six that are given. However, any combination of acquisitions may be attempted.

Table 4.3 Estimated Mitigation (MAF) at $10 PAF[1] in 26.7 Years

Year	Leased Water $30 PAF (Not adjusted)	Leased Water $30 PAF (Inflation adjusted)	Leased Water $132 PAF (Not adjusted)	Leased Water $132 PAF (Inflation Adjusted)	Purchased Water $1,450 PAF (Not adjusted)	Purchased Water $1,450 PAF (Inflation adjusted)
26.7	8.39	4.34	1.91	0.99	0.17	0.09

Source: Resource Dimensions, 2006.

4.6.2.1.2 Alternative Cycles

The quantity of mitigation that may be leased or purchased by the fund is dependent on the period of time between drought occurrences (frequency).

Table 4.7 reports the quantity of mitigation at $10 PAF that may be acquired in different time periods, based on duration of trust fund operation. These quantities are based on all funds being expended on a single acquisition category of the six that are given. However, any combination of acquisitions may be attempted.

Table 4.7 Estimated Mitigation (MAF) at $10 PAF over Various Time Periods

Year	Leased Water $30 PAF (Not adjusted)	Leased Water $30 PAF (Inflation adjusted)	Leased Water $132 PAF (Not adjusted)	Leased Water $132 PAF (Inflation Adjusted)	Purchased Water $1,450 PAF (Not adjusted)	Purchased Water $1,450 PAF (Inflation adjusted)
1	0.23	0.23	0.05	0.05	0.005	0.005
5	1.22	1.08	0.28	0.25	0.03	0.02
10	2.58	2.02	0.59	0.46	0.05	0.04
15	4.10	2.83	0.93	0.64	0.08	0.06
20	5.80	3.54	1.32	0.80	0.12	0.07
25	7.70	4.15	1.75	0.94	0.16	0.09
30	9.81	4.68	2.23	1.06	0.20	0.10

Notes: [1] Based on $7million in fees collected and deposited into trust fund annually

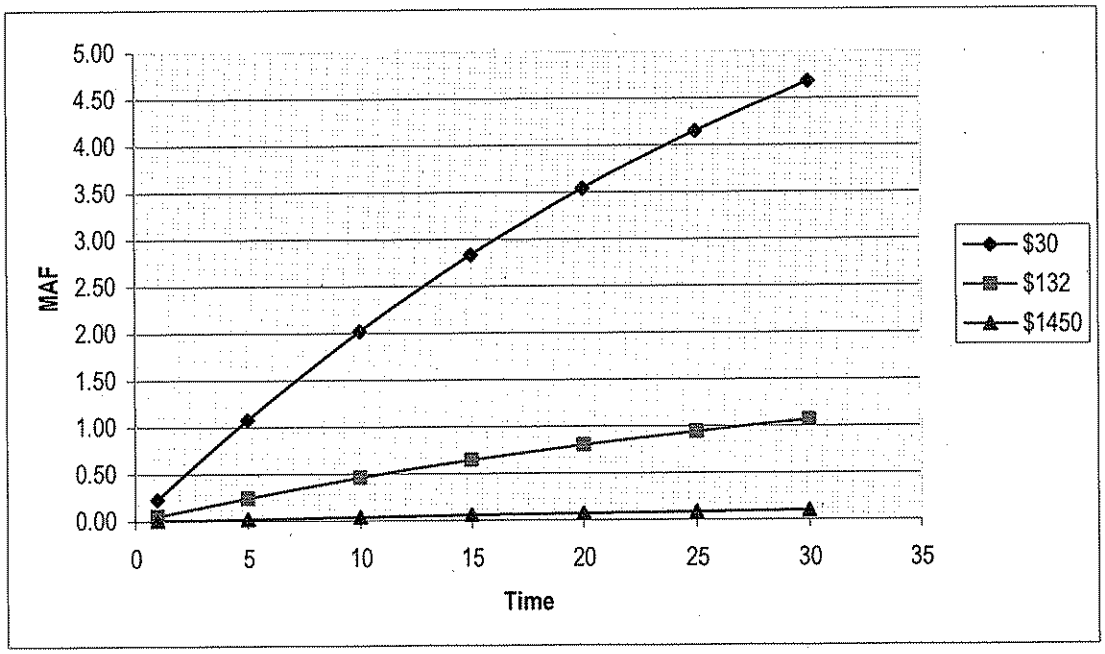
[2] Not adjusted for inflation

[3] Inflation adjusted

Figure 4.4 illustrates the different quantities of water that may be available for acquisition using mitigation funds accrued after various periods of operation. Only the inflation adjusted categories are included.

Attention should be given to the left hand scale for MAF when comparing this figure to similar figures for alternatives 2, 3 and 4.

Figure 4.4 Estimated Mitigation (MAF) at $10 PAF (0 to 30 years)



Source: Resource Dimensions, 2006.

4.6.2.2 Alternative 2: $20 Per Acre Foot

Under Alternative 2, 700,000 AF of new water permits are issued. New permit holders pay a $20 PAF annual fee for uninterruptible rights to the water. In this alternative, total fees of $14-million per year would be deposited in to a trust fund managed by the State. The analysis below estimates how much water may be acquired to mitigate instream flows during a drought period.

4.6.2.2.1 Estimated 26.7-year Cycle

If the assumptions in Section 4.5.1 are met, the future value of the mitigation trust fund would be worth $503.5 million at the 26.7-year interval.

As shown in Table 4.8, the amount of leased water that could be acquired by the fund ranges from a high of 16.78 MAF for water leased with **no price inflation** during the next 26.7-years (if available at non-drought prices) to a low of 1.97 MAF of water that experiences a 2.5% annual inflation rate, based on 2001 drought prices.

Acquisition of permanent or very long term water rights through purchase or BMP grant schemes may provide a maximum of 350,000 AF of water in 26.7-years, if no price inflation occurs, to a low of 180,000 AF if BMP technology inflation is limited to 2.5%.

These estimates are based on all funds being expended on a single acquisition category of the six that are given. However, any combination of acquisitions may be attempted.

Table 4.8 Estimated Mitigation (MAF) at $20 PAF[1] in 26.7 Years

Year	Leased Water $30 PAF (Not adjusted)	Leased Water $30 PAF (Inflation adjusted)	Leased Water $132 PAF (Not adjusted)	Leased Water $132 PAF (Inflation Adjusted)	Purchased Water $1,450 PAF (Not adjusted)	Purchased Water $1,450 PAF (Inflation adjusted)
26.7	16.78	8.68	3.81	1.97	0.35	0.18

Source: Resource Dimensions, 2006

4.6.2.2.2 Alternative Cycles

As stated in earlier sections, the quantity of mitigation that may be leased or purchased by the fund is dependent on the period of time between drought occurrences.

Table 4.9 reports the quantity of mitigation that may be acquired at $20 PAF in different time periods, based on duration of trust fund operation. These quantities are based on all funds being expended on a single acquisition category of the six that are given. However, any combination of acquisitions may be attempted.

Table 4.9 Estimated Mitigation (MAF) at $20 PAF over Various Time Periods

Year	Leased Water $30 PAF (Not adjusted)	Leased Water $30 PAF (Inflation adjusted)	Leased Water $132 PAF (Not adjusted)	Leased Water $132 PAF (Inflation adjusted)	Purchased Water $1,450 PAF (Not adjusted)	Purchased Water $1,450 PAF (Inflation adjusted)
1	0.47	0.46	0.11	0.10	0.010	0.009
5	2.44	2.16	0.55	0.49	0.05	0.04
10	5.16	4.03	1.17	0.92	0.11	0.08
15	8.21	5.67	1.86	1.29	0.17	0.12
20	11.60	7.08	2.64	1.61	0.24	0.15
25	15.39	8.30	3.50	1.89	0.32	0.17
30	19.63	9.36	4.46	2.13	0.41	0.19

Notes: [1] Based on $14 million in fees collected and deposited into trust fund annually.

[2] Not adjusted for inflation

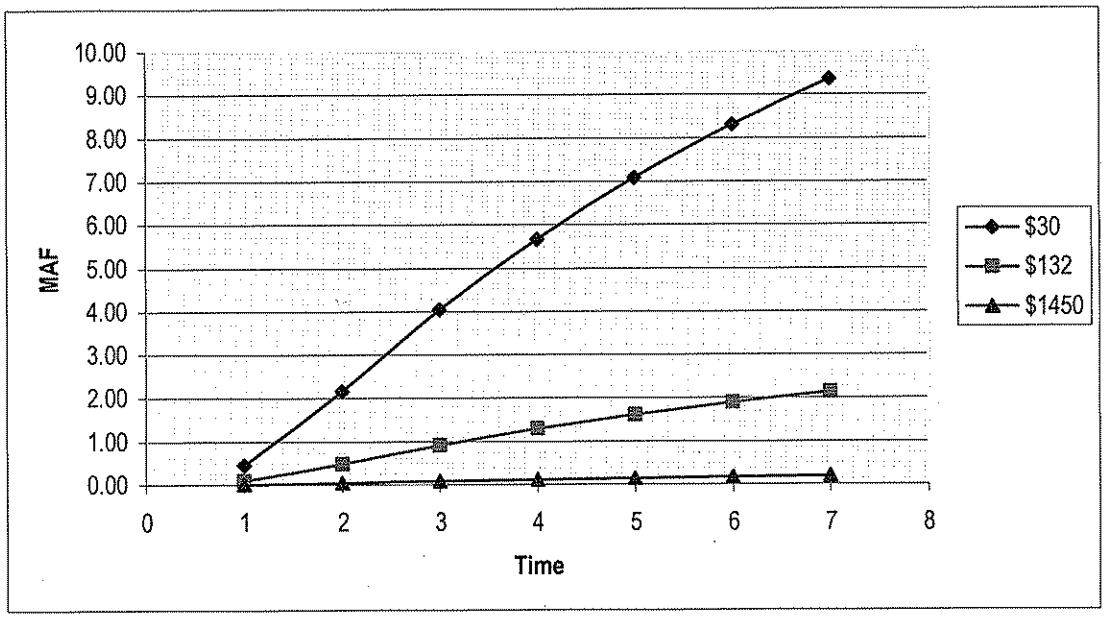
[3] Inflation adjusted

Source: Resource Dimensions, 2006

Figure 4.5 illustrates the different quantities of water that may be available for acquisition using mitigation funds accrued at $20 PAF after various periods of operation. Only the inflation adjusted categories are included.

Attention should be given to the left hand scale for MAF when comparing this figure to similar figures for alternatives 1, 3 and 4.

Figure 4.5 Estimated Mitigation (MAF) at $20 PAF (0 to 30 years)



Source: Resource Dimensions, 2006

4.6.2.3 Alternative 3: $30 Per Acre Foot

Under Alternative 3, 700,000 AF of new water permits are issued. New permit holders pay a $30 PAF annual fee for uninterruptible rights to the water. In this scenario, total fees of $21-million per year would be deposited in to a trust fund managed by the State. The following analysis estimates how much water may be acquired to mitigate instream flows during a drought period.

4.6.2.3.1 Estimated 26.7-year Cycle

If the assumptions in Section 4.5.1 are met, the future value of the mitigation trust fund would be worth $755.2 million at the 26.7-year interval.

As shown in Table 4.10, the amount of leased water that could be acquired by the fund ranges from a high of 25.7 MAF for water leased with **no price inflation** during the next 26.7-years (if available at non-drought prices) to a low of 2.96 MAF of water that experiences a 2.5% annual inflation rate, based on 2001 drought prices.

Acquisition of permanent or very long term water rights through purchase or BMP grant schemes may provide a maximum of 520,000 AF of water in 26.7-years, if no price inflation occurs, to a low of 270,000 AF if BMP technology inflation is limited to 2.5%.

These estimates are based on all funds being expended on a single acquisition category of the six that are given. However, any combination of acquisitions may be attempted.

Table 4.10 Estimated Mitigation (MAF) at $30 PAF in 26.7 Years

Year	Leased Water $30 PAF (Not adjusted)	Leased Water $30 PAF (Inflation adjusted)	Leased Water $132 PAF (Not adjusted)	Leased Water $132 PAF (Inflation Adjusted)	Purchased Water $1,450 PAF (Not adjusted)	Purchased Water $1,450 PAF (Inflation adjusted)
26.7	25.17	13.02	5.72	2.96	0.52	0.27

Source: Resource Dimensions, 2006

4.6.2.3.2 Alternative Cycles

The quantity of mitigation that may be leased or purchased by the fund is dependent on the period of time between drought occurrences (frequency).

Table 4.11 reports the quantity of mitigation that may be acquired at $30 PAF in different time periods, based on duration of trust fund operation. As with previous alternatives, quantities are based on all funds being expended on a single acquisition category of the six shown. However, any combination of acquisitions may be attempted.

Table 4.11 Estimated Mitigation (MAF) at $30 PAF over Various Time Periods

Year	Leased Water $30 PAF (Not adjusted)	Leased Water $30 PAF (Inflation adjusted)	Purchased Water $132 PAF (Not adjusted)	Purchased Water $132 PAF (Inflation Adjusted)	Purchased Water $1,450 PAF (Not adjusted)	Purchased Water $1,450 PAF (Inflation adjusted)
1	0.70	0.68	0.16	0.16	0.014	0.014
5	3.66	3.23	0.83	0.74	0.08	0.07
10	7.75	6.05	1.76	1.38	0.16	0.13
15	12.31	8.50	2.80	1.93	0.25	0.18
20	17.40	10.62	3.96	2.41	0.36	0.22
25	23.09	12.46	5.25	2.83	0.48	0.26
30	29.44	14.04	6.69	3.19	0.61	0.29

Notes: [1] Based on $21 million in fees collected and deposited into trust fund annually.

[2] Not adjusted for inflation

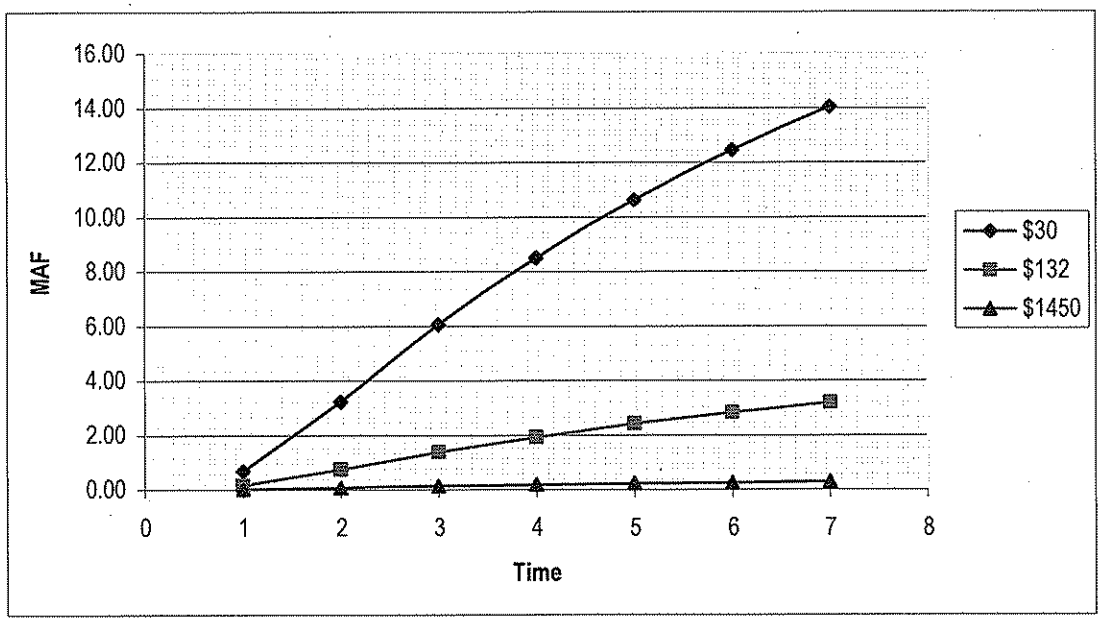
[3] Inflation adjusted

Source: Resource Dimensions, 2006

Figure 4.7 illustrates the different quantities of water that may be available for acquisition using mitigation funds accrued after various periods of operation. Only the inflation adjusted categories are included.

Attention should be given to the left hand scale for MAF when comparing this figure to similar figures for alternatives 1, 2 and 4.

Figure 4.7 Estimated Mitigation (MAF) at $30 PAF (0 to 30 years)



Source: Resource Dimensions, 2006.

4.6.2.4 Alternative 4: $75 Per Acre Foot

Under Alternative 4, 700,000 AF of new water permits are issued. New permit holders pay a $75 PAF annual fee for uninterruptible rights to the water. In this scenario, total fees of $52.5-million per year would be deposited in to a trust fund managed by the State. The following analysis estimates how much water may be acquired to mitigate instream flows during a drought period.

4.6.2.4.1 Estimated 26.7-year Cycle

If the assumptions in Section 4.5.1 are met, the future value of the mitigation trust fund would be worth $1,888 million at the 26.7-year interval.

As indicated in Table 4.12, the amount of leased water that could be acquired by the fund ranges from a high of 62.93 MAF for water leased with **no price inflation** during the next 26.7 years (if it available at non-drought prices) to a low of 7.40 MAF of water that experiences a 2.5% annual inflation rate, based on 2001 drought prices.

Acquisition of permanent or very long term water rights through purchase or BMP grant schemes may provide a maximum of 1.30 MAF of water in 26.7-years, if no price inflation occurs, to a low of 670,000 AF if BMP technology inflation is limited to 2.5%.

These estimates are based on all funds being expended on a single acquisition category of the six that are given. However, any combination of acquisitions may be attempted.

Table 4.12 Estimated Mitigation (MAF) at $75 PAF in 26.7 Years

Year	Leased Water $30 PAF (Not adjusted)	Leased Water $30 PAF (Inflation adjusted)	Leased Water $132 PAF (Not adjusted)	Leased Water $132 PAF (Inflation Adjusted)	Purchased Water $1,450 PAF (Not adjusted)	Purchased Water $1,450 PAF (Inflation adjusted)
26.7	62.93	32.55	14.30	7.40	1.30	0.67

Source: Resource Dimensions, 2006.

4.6.2.4.2 Alternative Cycles

The quantity of mitigation that may be leased or purchased by the fund is dependent on the period of time between drought occurrences (frequency).

Table 4.13 reports the quantity of mitigation that may be acquired in different time periods, based on duration of trust fund operation. These quantities are based on all funds being expended on a single acquisition category of the six that are given. However, any combination of acquisitions may be attempted.

Table 4.13 Estimated Mitigation (MAF) at $75 PAF over Various Time Periods

Year	Leased Water $30 PAF (Not adjusted)	Leased Water $30 PAF (Inflation adjusted)	Purchased Water $132 PAF (Not adjusted)	Purchased Water $132 PAF (Inflation Adjusted)	Purchased Water $1,450 PAF (Not adjusted)	Purchased Water $1,450 PAF (Inflation adjusted)
1	1.75	1.71	0.40	0.39	0.036	0.035
5	9.15	8.09	2.08	1.84	0.19	0.17
10	19.36	15.13	4.40	3.44	0.40	0.31
15	30.77	21.25	6.99	4.83	0.64	0.44
20	43.51	26.55	9.89	6.03	0.90	0.55
25	57.73	31.14	13.12	7.08	1.19	0.64
30	73.61	35.09	16.73	7.98	1.52	0.73

Notes: [1] Based on $52.5 million in fees collected and deposited into trust fund annually.

[2] Not adjusted for inflation

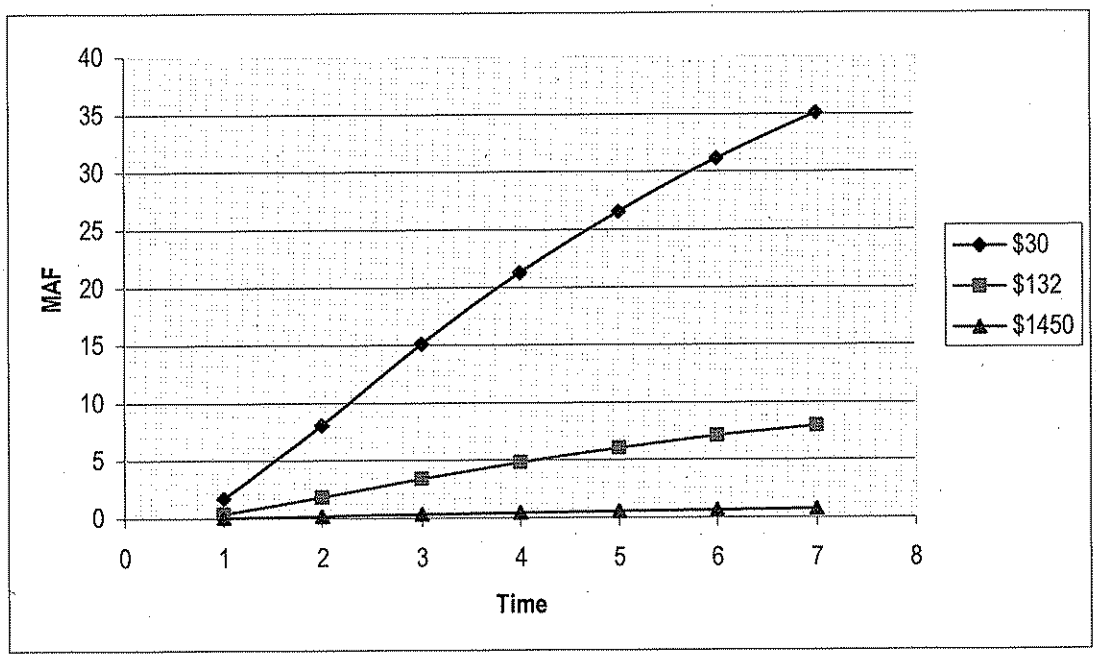
[3] Inflation adjusted

Source: Resource Dimensions, 2006

Figure 4.8 illustrates the different quantities of water that may be available for acquisition using mitigation funds accrued after various periods of operation. Only the inflation adjusted categories are included.

Attention should be given to the left hand scale for MAF when comparing this figure to similar figures for alternatives 1, 2 and 3.

Figure 4.8 Estimated Mitigation (MAF) at $75 PAF (0 to 30 years)



Source: Resource Dimensions, 2006.

4.7 Summary

4.7.1 26.7 year drought cycle

Alternative 1, the status quo scenario proposed by Washington state will require a $10 PAF mitigation fee be paid annually for new water rights. The collected fees will amount to $7-million per year which will accumulate in a State Trust Fund. The funds held in this trust will be withdrawn and spent when instream flow mitigation is necessary. If the financial assumptions in Section 4.5.1 are met $251.7 million will be available after 26.7-years.

Alternative mitigation fees were proposed by policy alternatives (PA) 2, 3 and 4. When all other relevant factors are held constant (i.e., interest rate and time duration) we expect the total available funds to be directly proportionate to fees collected. Under this assumption, the following values were determined for each alternative:

- PA 2 proposes a $20 PAF annually for the new water rights. This results in $14 million deposited annually in to the trust for a total fund of $503.5 million available after 26.7-years.

- PA 3 proposes a $30 PAF annually for the new water rights. This results in $21 million deposited annually in to the trust for a total fund of $755.2 million available after 26.7-years.

- PA 4 proposes a $75 PAF annually for the new water rights. This results in $52.5 million deposited annually in to the trust for a total fund of $1,888 million available after 26.7-years.

To translate available funds in the trust in to the quantity of water that may be acquired for mitigation acquisition costs must be considered. The main consideration being how much inflation has increased the value over the intervening 26.7-years. Assuming 2.5% inflation, prices will have increased 193% in 26.7-years.

Assuming these values, Table 4.14 lists the quantity of water that may be purchased under each policy mitigation fee and mitigation acquisition cost alternative combination. Costs are adjusted for inflation.

Table 4.14 Estimated Mitigation (MAF) in Year 26.7 of Trust Fund

Alternative	AC$30	AC$132	AC$1,450
1 - Status Quo	4.340	0.986	0.090
2 - PA$20	8.680	1.973	0.180
3 - PA$30	13.020	2.959	0.269
4 - PA$75	32.550	7.398	0.673

Notes: AC = water acquisition costs alternative. PA = policy based alternative mitigation fees.

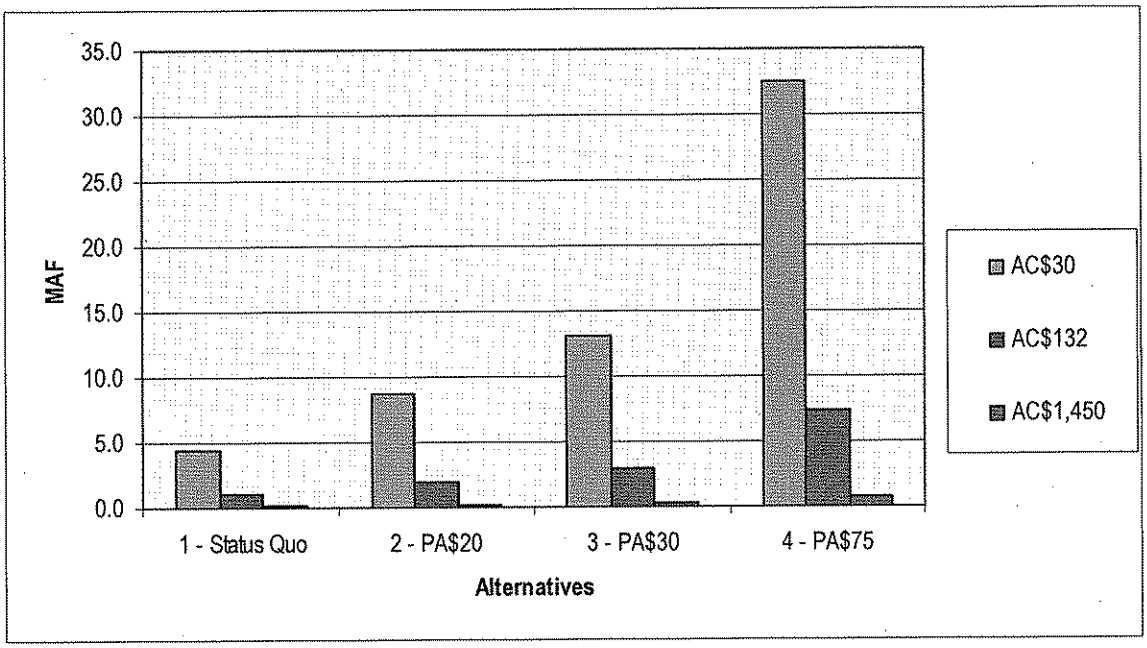
Source: Resource Dimensions, 2006

In conducting a comparison between the various fee alternatives, it should be noted that each $10 PAF fee increment accrued in the trust will provide funds to lease about 1 MAF of water, assuming a drought lease price of $255 PAF. ($255 is the inflation adjusted price based on 2006 value of $132).

A $10 PAF fee increment applied in the same manner as discussed above will provide funds to lease about 4.3 MAF of water or purchase 90,000 AF of water (assuming non-drought prices). These quantities are based on the inflation adjusted costs of $58 PAF leased per year and $2,803 PAF purchase price, each are price adjusted for inflation.

Figure 4.9 illustrates the different quantities of water that may be purchased under the four fee-based policy alternatives and the three possible acquisition costs alternatives (inflation adjusted) using mitigation funds accrued over 26.7-years.

Figure 4.9 Estimated Mitigation (MAF) in Year 26.7 of Trust Fund



Source: Resource Dimensions, 2006.

4.7.1 5 and 10 year drought cycles

In this analysis the total funds available and water acquisition mitigation costs are directly dependent on how much time passes before funds must be withdrawn and spent.

As previously stated, we find no justification for the use of a 26.7-year drought cycle to predict the interval of time in which funds would be required for mitigation.

To provide a context for comparison we present analysis of mitigation trust fund withdraws and expenditures at 5 and 10 years. The same analysis is carried out on fees and costs with the time period from program initiation to demand for mitigation measures being the only difference.

Table 4.15 lists the quantity of water that may be purchased after the fifth year of fund operation under each policy mitigation fee and mitigation acquisition cost alternative combination. Costs are adjusted for inflation.

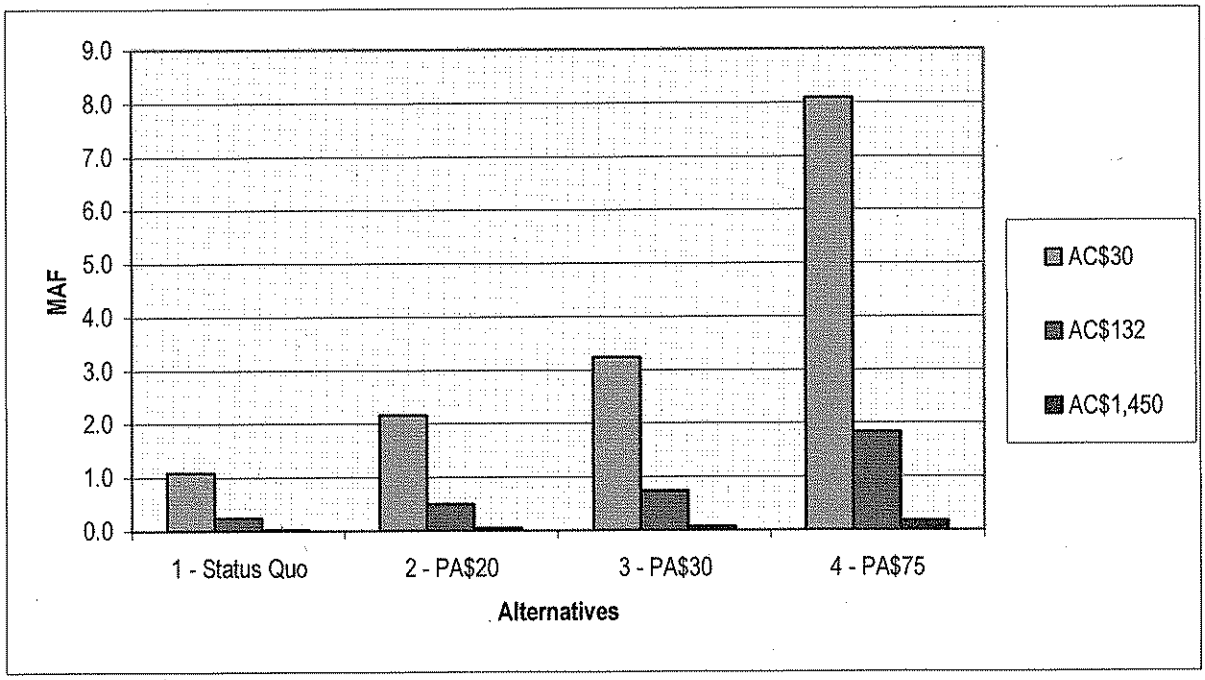
Table 4.15 Estimated Mitigation (MAF) in Year 5 of Trust Fund

Alternative	AC$30	AC$132	AC$1,450
1 - Status Quo	1.078	0.245	0.022
2 - PA$20	2.156	0.490	0.045
3 - PA$30	3.235	0.735	0.067
4 - PA$75	8.086	1.838	0.167

Source: Resource Dimensions, 2006.

Figure 4.10 illustrates the different quantities of water that may be purchased under the four fee-based policy alternatives and the three possible acquisition cost alternatives (inflation adjusted) using mitigation funds accrued over 5-years.

Figure 4.10 Estimated Mitigation (MAF) in Year 5 of Trust Fund



Source: Resource Dimensions, 2006.

Table 4.16 lists the quantity of water that may be purchased after the tenth year of fund operation under each policy mitigation fee and mitigation acquisition cost alternative combination. Costs are adjusted for inflation.

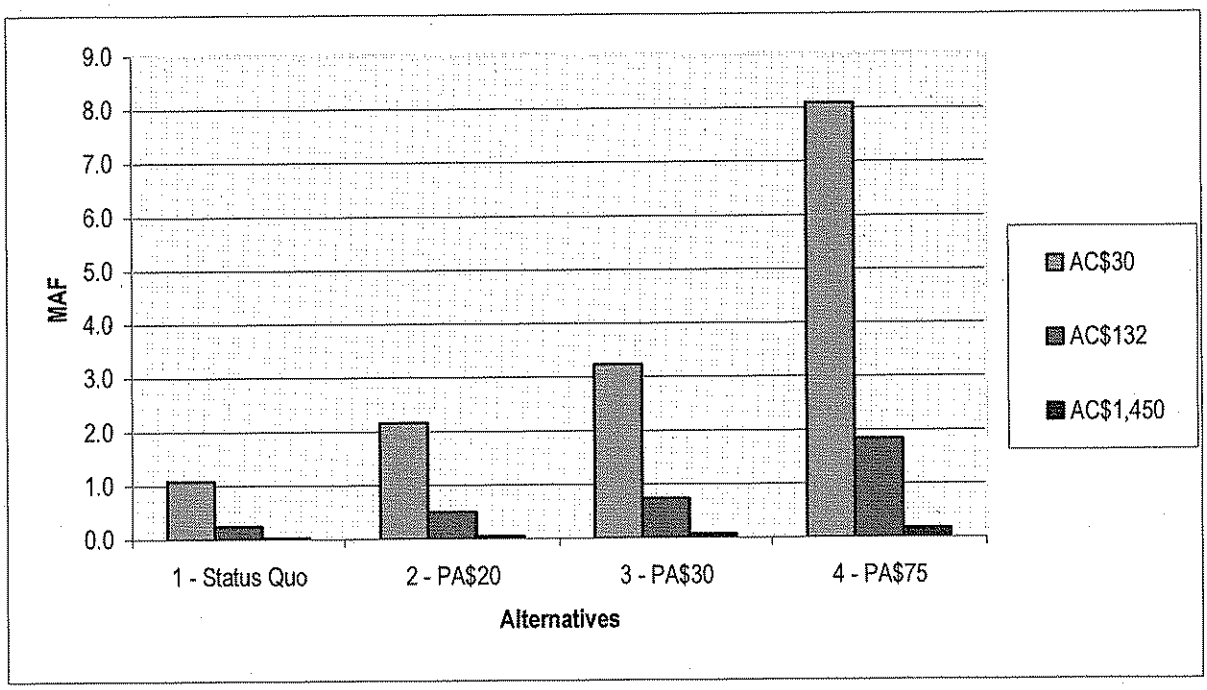
Table 4.16 Estimated Mitigation (MAF) in Year 10 of Trust Fund

Alternative	AC$30	AC$132	AC$1,450
1 - Status Quo	2.017	0.458	0.042
2 - PA$20	4.034	0.917	0.083
3 - PA$30	6.051	1.375	0.125
4 - PA$75	15.128	3.438	0.313

Source: Resource Dimensions, 2006.

Figure 4.11 illustrates the different quantities of water that may be purchased under the four fee-based policy alternatives and the three possible acquisition cost alternatives (inflation adjusted) using mitigation funds accrued over 10-years.

Figure 4.11 Estimated Mitigation (MAF) in Year 10 of Trust Fund



Source: Resource Dimensions, 2006.

Over a 5-year period, the status quo fee of $10 PAF would provide funds to lease about 245,000 AF of water assuming a drought lease price of $149 PAF, the inflation adjusted price based on 2006 value of $132. Alternative 2, $20 PAF, would provide funds for 490,000 AF of water. Alternative 3, $30 PAF, would provide funds for 735,000 AF of water.

A $10 PAF mitigation fee increment applied in the same manner as above provide funds to lease about 1 MAF of water or purchase 2,200 AF of water assuming non-drought prices. These quantities are based on the inflation adjusted lease costs of $34 PAF per year and $1,640 PAF purchase price, each price adjusted for 5-years inflation at 2.5%.

Section 5: Conclusions & Recommendations

5.1 Mitigation Values: Policy & Planning Implications

The purpose of this study was to address a question:

> What level of fees should be levied on new water diversions within the Columbia River basin to assure that sufficient mitigation funds will be available to protect instream requirements in the future?

To determine the answer the future costs of water acquisition must be estimated; the future value of the mitigation trust fund and calculating how much water could be purchased is straight forward. Results are shown within the tables and figures found in Section 4.6.3.

There is no dispute that a mitigation fee program will provide necessary financial resources for water purchases in the future. However, what this analytic process has shown is that there are uncertainties and risks to using a mitigation fee and trust fund approach. If these uncertainties and risks are not appropriately addressed and allowed for in the mitigation fee program there is a predisposition toward insufficient available funds to acquire water for instream flow in the future.

Some of the uncertainties and risks that have been identified are:

- The length of time the fund will be able to accumulate is not certain. A period of 26.7-years has been used by some parties. No substantial justification for this cycle has been given, especially in the context of changing global climate and the drought experience of the last 15 years. Shorter drought cycles of 5, 10 or 15-years will significantly decrease the available funds.

- When droughts do occur, their duration is significant. A multi-year drought fundamentally changes the amount of funds that can be spent in any one year on mitigation. Funds should be held in reserve in anticipation of a drought lasting 2, 3 or more years. This implies that only 50%, 33%, 25% of the total fund may actually be available in the first year of drought.

- It is uncertain how many acre-feet of water will need to be acquired in a drought year. The severity of drought, both in its intensity and geographic breadth, has implications for the amount of mitigation that will be required.

- There is no certainty that sufficient quantities of water will be offered for sale in the market. The very essence of droughts is that there is a shortage of water, thus there is less water available for sale at any given price.

- The creation of an open and active market for water is important for the efficiency of this program. There are no assurances that a more effective and efficient market for water transfers will occur regardless the intentions of the State.

- There is risk that the accumulating mitigation fees will not be completely held in the trust until drought mitigation is required. If operational expenses are charged to the fund or if non-drought mitigation acquisitions are made prior to a drought, the trust fund will be diminished and predicted purchases of water will not made when a drought does occur.

Together, these uncertainties increase the likelihood that an insufficient mitigation fee will lead to insufficient funds being available when a drought does occur.

5.2 Recommendations

The objective of the trust fund is to provide financial resources for drought mitigation in the future. The basic program has little risk of not performing that function. However, there are uncertainties and risk inherent in the amount of funding that will be available and if the necessary water will be available for acquisition. There are several actions and policies that can increase the ability of the program to meet its ambition to provide resources for an uncertain future.

The mitigation fee should be set at the $30 PAF level until adequate risk assessment demonstrates that a lower fee will provide the necessary funds. The program is at its most vulnerable to failure to provide in its first years of operation before annual deposits start to accumulate in the trust to a significant level.

The mitigation fee should be set and systematically adjusted based on the stated purpose of the program; to provide sufficient monetary resources for drought mitigation. A formal and public analysis of the predicted needs and appropriate measures to meet those needs should be made. A model that could prove useful in this endeavor is that of a defined benefits pension fund.

Washington state should have a commitment in place to provide supplemental funds to the mitigation fund if the accumulated monetary resources are not sufficient to provide the requisite mitigation measures.

To overcome any possibility that the commercial marketplace for water will not provide sufficient water for mitigation purposes the program should have the right of first refusal for any water being offered for lease or sale during a drought period.

There is a major need for further study to provide important information for managing the fund to meet its obligation of mitigating a future drought. Much of the research and study to date that has been sponsored by the State appears to be ex-post to support the $10 PAF fee that was reached by negotiation, not science.

References

Blumm, M. C., and B. M. Swift. 1997. A Survey of Columbia River Basin Water Law Institutions and Policies at vii, A Report to the Western Water Policy Advisory Commission (Dec. 1997).

Cohen, S.J., K.A. Miller, A.F. Hamlet and W.Avis. 2000. Climate change and resource management in the Columbia River Basin. *Water International.* Vol 25, No. 2 Pages 253-272.

Cone, J. and S. Ridlington 1996. The Northwest Salmon Crisis: A Documentary History. Corvallis, Oregon: Oregon State University Press.

Dick, L. H., Jr., 1990. Water is a medicine: it can touch your heart. *Oregon Humanities* Winter, p. 8-10.

Gedalof, Z., D. L. Peterson, and N. J. Mantua, 2004. Columbia River Flow and Drought Since 1750. Journal of the American Water Resources Association, , December, 2004, pp 1579-1592.

Getches, D. H. 1997. *Water Law in a Nut Shell*, St. Paul, Minnesota: West Publishing Co.

Hamlet, A. F. and D. P. Lettermaier, 1999. Effects of Climate Change on Hydrology and Water Resources in the Columbia River Basin. Journal of the American Water Resources Association 35:1597-1623.

Hamlet, A.F., D. P. Lettenmaire and B.Nijssen. 1998. Effects of climate shift on water resources objectives in the Columbia Basin. Year Three Progress Report, JISAO Climate Impacts Group Report, University of Washington. Seattle, WA.

Hamlet, A.F., D. P. Lettenmaire and B.Nijssen. 1997. Effects of climate shift on water resources objectives in the Columbia Basin. JISAO Climate Impacts Group Report, University of Washington. Seattle, WA.

Hanes, R. C. and R.. Hanis, 1995. Interactions of North American Indian Nations and Ethnic Groups with the Natural Environment. Interior Columbia Basin Ecosystem Management Project. June 95.

Hunn, D., 1990. *Nch'i-Wana, "Big River": Mid-Columbia Indians and Their Land.* University of Washington Press: Seattle, WA.

Rosenberg, N. J., ed., (1979) Drought in the Great Plains - Research on impacts and strategies: Proceedings of the Workshop on Research in Great Plains Drought Management Strategies, University of Nebraska, Lincoln, March 26-28: Littleton, CO, Water Resources Publications, 225 p. Available at: U.S. Department of Interior, US Geological Survey, Definitions of Drought: http://md.water.usgs.gov/drought/define.html

Fritz Stempel, et al v. State of Washington, Department of Water Resources, 82 Wn.2d 109, 508 P.2d 166 (1973)

Alberta Low Thompson v. Martha Short, 6 Wn.2d 71, 106 P.2d 720 (1940)

U.S. Department of the Interior, 2000. US Geological Survey, Definitions of Drought; available at: http://md.water.usgs.gov/drought/define.html

U.S. Department of the Interior, US Geological Survey, Water Watch Program, 2006. Past streamflow conditions: average runoff (mm/day), by water-year, for Washington state. Available at: http://water.usgs.gov/waterwatch/?m=statesum&r=wa

Waldeck, D.A. and E. H. Buck. 1999. The Pacific Salmon Treaty: The 1999 Agreement in Historical Perspective. Congressional Research Service Report RL30234.

Washington State, Department of Ecology, Relationship of CFS to instream flow available at: http://www.ecy.wa.gov/programs/wr/instream-flows/isfhm.html

Washington State, Office of Financial Management, Fiscal Note for SB6581 published 2 April 2006. Available at: http://www.ofm.wa.gov/fns/LegSearch.asp?BillNumber=6581&SessionNumber=59

Yevjevich Vujica, Hall, W. A., and Salas, J.D, eds., 1977, Drought research needs, in Proceedings of the Conference on Drought Research Needs, December 12-15, 1977: Colorado State University, Fort Collins, Colorado, 276 p.

Appendices

Appendix A: WWT Water Rights Lease Transactions (2000-2005)

Appendix B: Columbia Basin Water Transfer Partnership Water Rights Transactions (2002-2005)